Producibility Evaluation Criteria
Cost Estimating Computer Programs - Manual

U. S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION, NAVAL SURFACE WARFARE CENTER

in cooperation with

Newport News Shipbuilding

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
DEC 1993	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Producibility Evaluation Criteria Cost Estimating Computer Programs - Manual	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230-Design Integration Tools Bldg 192, Room 128 9500 MacArthur Blvd, Bethesda, MD 20817-5000**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**97**	

PRODUCIBILITY EVALUATION CRITERIA

Cost Estimating Computer Programs - Manual

Providing guidance for use of several computer programs which have been developed by SNAME Panel SP-4 for determining the cost of construction of a ship or portion of a ship, or for determining which of several design alternatives will be the least expensive to build and which will be the best choice to select, considering all elements of the decision-making process.

Chapter 1 - INTRODUCTION

This manual has been prepared to describe the use of a number of computer programs that have been developed for evaluating the producibility and desirability of different ship design alternatives. These programs are included on a floppy disk which accompanies this manual. The background of their development is descibed in reference 1 and will not be repeated here.

This manual is intended as a "How-To" document and consequently will be presented primarily in the second person as if giving hands-on advice, looking over your shoulder.

The description which follows assumes familiarity with entering data into personal computers. Specifically, rather than stating "press the enter key" each time that this statement is required, this will be assumed to be understood whenever the direction to "enter" data is given The commands to be entered will be shown in this manual in bold capitals, but when actually entering commands or data, lower case may be used.

Whenever a line on a screen asks for entry of a single letter choice from several listed possibilities, such a Y or N for yes or no, the default choice will be bracketed by the <> symbols. In such cases, the enter key may be processed to select the default choice.

The floppy disk which accompanies this manual includes the GW-BASIC application on the main directory. The programs on the disk are filed in one of the three subdirectories, which are identified as "COST", "PROD" and "DEC". Chapter 2 of this Manual addresses the use of the programs in the COST subdirectory, Chapters 3 and 4 address the programs in the PROD subdirectory and Chapter 5 describes the use of the DEC subdirectory files. All of the programs on the disk are either written in GW-BASIC and run using that application program or they are spreadsheets in LOTUS 123 format

The GW-BASIC statements that are used in the programs in the PROD subdirectory are written out in the Appendix The programs in the DEC subdirectory are identical in concept and use, varying only in the criteria that are considered within the programs. The DEC program statements, as well as the PROD program statements, can be obtained from within the GW-BASIC shell by loading the individual program and typing "LIST".

The producibility criteria and decision-making criteria used in these programs are those which were determined during the research described in Reference 1. The programs provided with this manual use the weighting factors that were obtained during that research effort Chapter 4 provides detailed instructions on the use of the computer programs used to determine those weighting factors and to reevaluate them when necessary.

If you have any questions concerning how to use or to modify these programs for your specific use, call 1-800-347-7689.

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Chapter 2- THE COST ESTIMATING COMPUTER PROGRAMS

GENERAL

The programs described in this chapter are located in the COST subdirectory. These programs are used for estimating the manhours and cost for constructing what the design describes. By applying these programs to each alternative design of a particular aspect of a ship design that is under consideration% you will develop an estimate of the manhours and cost to build each of them. By definition, the alternative that requires the least manhours and cost will be the most producible.

The cost estimating computer programs are in spreadsheet format and are designed for use with Lotus 123 Release 2.0 or later. Translation of the programs to several other spreadsheet application programs has been successfully accomplished. Use of the programs in any application program that accepts 123 data input should present no problem. To obtain more detail on the use of these programs, enter "CD\COST", and then "README".

The basic concept of the cost estimating programs is to go through on paper, all of the processes by which the design under evaluation will be build identfying the quantity of work that will be required for each of those processes. For various types of work there are different parameters which determine how many manhours will be required to complete the process. Thus, for welding, the length of weld is the primary determining factor, while, for bending pipe, the number of bends will control the amount of work expressed in manhours, that will be required.

In addition the actual stage of the construction cycle in which each of the work processes will be performed must be determined. Work done at a stage later than that at which it can be accomplished most efficiently will necessarily require more manhours to accomplish.

These data are entered into the appropriate rows and columns of the spreadsheet by an operator and the program calculates the required manhours. Based on the dollar cost per manhour that has been entered into the program the labor costs are also calculated. Material costs are calculated separately and added to the manhour costs to generate total cost.

Separate programs have been provided for work done by the structural piping, HVAC, and electrical trades. Within structures and piping, separate programs have been provided for different types of materials. The following programs are provided in the COST subdirectory

PIPICFE.WK1	- For Carbon Steel P1 Piping installations
PIPICRES.WK.1	- For CRES P1 Piping installations
PIPINICU.WK1	- For Copper-Nickel P1 Piping installations
PIP2CFE.WK1	- For Carbon Steel P2 Piping installations
PIP2CRES.WK 1	- For CRES P2 Piping installations
PIP2NICU.WK1	- For Copper-Nickel P2 Piping installations
STRCTMS.WK1	- For Mild Steel Structural work
STRTHY80.WK1	- For HY80 Steel Structural work
STRCTHTS.WK1	- For HTS Steel Structural work
STRCTAL.WKI	- For Aluminum Structural work

HVAC.WK1	- For HVAC System installations
ELECT.WK1	- For Electrical System installations

The Appendix provides a copy of each of the above mentioned forms, and of the data used to generate the process factors.

DESCRIPTION

General - Each of the cost estimating computer programs is in a similar format. Most of the fields in the forms are protected, so that you cannot accidentally change them. The description that follows addresses only those fields into which you are expected to enter data. Figure 2-1 shows how the screen will appear for entering structural data into the mild steel structural form.

Project Title - Spaces are provided at the top of each form for inserting the name of the project and the new file name to be used for the specific design variant being evaluated. The project name of "TEST" and the file name of "STRUCTVAR "have been entered in the appropriate fields in Figure 2-1.

Material Parameters - In the next line or lines, fields are provided for entering the specific size or thickness or other controlling parameters of the material covered by the form. The same basic form may be used for several different sizes of the form's rnateriaL but not in general for different materials. For example, the form for Mild Steel structure maybe used for material thicknesses from 1/4 inch to 2 inches, but a different form is needed for HY-80 materials. Similarly, the form for steel pipe can be used for piping diameters from 3/8" to 8" piping installations and for schedules 40, 80 or 120, but a different form is needed for CuNi piping.

In Figure 2-1,0.5 inch has been entered into the material thickness field. After entering this value, press the F9 key to obtain the correct values to be used for the Work Factors. The computer program generates these values from a "Look-Up" table that is stored on the same spreadsheet form. The content of the lookup tables for each of the various forms are included with copies of the forms in the Appendix.

Data Entry - You or other Engineers or Cost Estimators, noting the work factors identified in the Work Factor column for each Work Process, need to evaluate the design and how it would be constructed, to determine the quantity of each of the controlling work factors involved in the design. For instance, you must know the number of pieces, the number of feet of weld, the number and type of pipe joints-or bends, the number of feet of electrical cable to be pulled, etc. Enter these values into the Unit Amount field opposite the process to which they pertain.

In Figure 2-1, the value of 100 has been entered into the Unit Amount column for the work process of Obtaining Materials, 20 feet of manual flame cutting is required, and 40 feet of flat grinding is required for edge preparation.

Work Stage - The various Work Stages considered in this project are listed below., along with the multiplying factor used in determining the effect of accomplishing work in later than the optimum stage for minimum manhours. These values also are contained in a lookup table on each spreadsheet form and the related multiplication factors are automatically applied when the Actual Stage is different than the Standard Stage.

Work Stage	Definition	Multiplier
1. Fabrication	In Shop	1.0
2. Preoutfitting Hot	On Platen - Hot Work	1.5
3. Paint	Paint Shop	2.0
4. Preoutfitting Cold	On Platen - Cold Work	4.0
5. Erection	Building Ways - On Block	5.0
6. Outfitting	Building Ways - Enclosed	7.0
7. Waterborne	Pierside after Launch	10.0
8. Tests and Trials	Pierside and Underway	15.0

When using these forms during early stage design efforts, it would be reasonable to assume that all of the work when done, will be accomplished at the ideal or standard work stage. In that case, no changes would be needed in the column headed "Actual Stage", since the form is prepared with the the two columns having identical values. For ships that are already in

```
    *A* *          C          **    D    **   E  **   F   **  G  **   H  *
1   NSRP PANEL SP-4                          COST  ESTIMATING  FORM  FOR
2   FILE:  STRCTMS                               STRUCTURAL  WORK
3   4/1/1992
4                    PROJECT: "TEST"                 MATERIAL:       MS-STS
5                    FILE :   STRCTVAR               THICKNESS      .5  INCHES
6
7      WORK PROCESS                 WORK    PROCESS      UNIT ACTUAL STANDRD
8                                   UNITS   FACTOR     AMOUNT  STAGE   STAGE
9                                           (MNHRS/
10                                             UNIT)
11
12     1 OBTAIN MATERIAL            SQ FT      .100        100      1       1
13       RECEIPT & PREP
14
15     2 FLAME CUTTING
16         AUTOMATIC                LN FT      .050          0      1       1
17         MANUAL                   LN FT      .090         20      7       2
18
19     3 EDGE PREP-GRINDING
20         FLAT                     LN FT      .040         40      7       2
```

Figure 2-1

construction, however, or for work to be done during an overhaul much of the work may have to be done on board, in poor working environments, instead of in the shop or wherever the 'work could be done most productively. In these cases, the stage at which the work will actually be accomplished must be entered into this column for each work process.

The value of 7, corresponding to the Waterborne work stage, has been entered into the Actual Stage column for the flame cutting process.

Manhours - When all of the data described above has been entered into the spreadsheet form the manhours required for each of the processes will be calculated in the rightmost column In Figure 2-2, which is a printout of the entire spreadsheet form (which is too large to be seen the computer screen at one time) 12 manhours are shown to be required for flame cutting, a val obtained by multiplying .090 manhours per foot by 20 feet times the work stage multiplier ratio 10.0/1.5.

Total Manhours -he total number of direct manhours will be indicated at the bottom of the Manhours column. The value of 394 manhours is shown in Figure 2-2.

Means has been provided for identifying a manhour multiplication factor, in order to account for the assist trade manhours. This is set at 35°A in the tables provided and has been p in a protected field but this can be "unprotected" and changed for any situation when that is considered appropriate. The sum of direct and assist trade manhours is then listed, as well In Figure 2-2, the values 138 and 532 have been calculated for the assist manhours and total manh- ours, respectively.

Manhour Cost - To obtain the labor cost the total manhours are multiplied by a Dollars per Manhour figure. This figure also is in a protected field which can be changed easily to meet actual conditions. A value of $20.00 has been used in the forms initially provided yielding a lab cost of $10,639.

Material Cost - The material cost must be calculated separately. However, once deter- mined, the value for material cost can be entered into the format the bottom to generate the tota cost for construction of the system that is being considered. The value of $750 has been used fo the material cost in Figure 2-2.

Total Cost - The total cost of the entire design will appear at the bottom of the screen when all of the data involved has been entered. Figure 2-2 shows the value of $11,389.

SAVE

When all of the data has been entered and all of the calculations have been completed, SAVE the form using a unique file name that describes the evaluation that has been made.

REPORT

The information entered into and calculated by the program would normally be printed out in hard copy for review and recording the results. As previously indicated, Figure 2-2 is an example of the result of doing so.

COMPARATIVE ANALYSES

The same forms may be used for identiying the cost differences between two alternative designs, by entering, into each work process, the differences of work units between the two alter natives. Thus if Alternative 1 requires 85 feet less of flame cutting than another alternative, ente 85 feet and the result will be the manhour and cost savings to be achieved by selecting Alt 1 as the design to use. Likewise, if some aspect of one design alternative (or one production ap- proach) allows more work to be done in the shop instead of being done on board, the effect of t work stage change can be directly calculated. Examples are provided in Reference 1.

NSRP PANEL SP-4
FILE: STRCTMS
4/1/1992

COST ESTIMATING FORM FOR
STRUCTURAL WORK

PROJECT: "TEST"
FILE : STRCTVAR

MATERIAL THICKNES: MS-STS .5 INCHES

WORK PROCESS	WORK UNITS	PROCESS FACTOR (MNHRS/ UNIT)	UNIT AMOUNT	ACTUAL STAGE	STANDRD STAGE	ACTUAL FACTOR	STANDRD FACTOR	MNHRS REQ'D
1 OBTAIN MATERIAL RECEIPT & PREP	SQ FT	.100	100	1	1	1.0	1.0	10
2 FLAME CUTTING								
AUTOMATIC	LN FT	.050	0	1	1	1.0	1.0	0
MANUAL	LN FT	.090	20	7	2	10.0	1.5	12
3 EDGE PREP-GRINDING								
FLAT	LN FT	.040	40	7	2	10.0	1.5	11
VERTICAL	LN FT	.060	0	2	2	1.5	1.5	0
OVERHEAD	LN FT	.080	0	2	2	1.5	1.5	0
4 SHAPING								
BREAK	BEND	.480	1	1	1	1.0	1.0	0
ROLLING	PIECE	1.200	0	1	1	1.0	1.0	0
LINE HEATING	PIECE	10.000	0	1	1	1.0	1.0	0
FURNACE	PIECE	15.000	0	1	1	1.0	1.0	0
PRESS	PIECE	.024	0	1	1	1.0	1.0	0
MACHINING	CU IN	.020	0	1	1	1.0	1.0	0
5 FIT UP & ASSEMBLY	DK/BR JOINT	.560	4	7	2	10.0	1.5	15
6 WELDING, AUTO /MACHINE								
FILLET	LN FT	.065	0	2	2	1.5	1.5	0
BUTT	LN FT	.480	0	2	2	1.5	1.5	0
7 WELDING, MANUAL								
FILLET								
DOWNHAND	LN FT	1.600	10	7	2	10.0	1.5	107
VERTICAL	LN FT	1.920	0	2	2	1.5	1.5	0
OVERHEAD	LN FT	2.240	10	7	2	10.0	1.5	149
BUTT								
DOWNHAND	LN FT	1.600	0	2	2	1.5	1.5	0
VERTICAL	LN FT	1.920	0	2	2	1.5	1.5	0
OVERHEAD	LN FT	2.240	0	2	2	1.5	1.5	0
8 MARKING	PIECE	.100	3	7	1	10.0	1.0	3
9 HANDLING								
STORAGE	PIECE	.100	3	2	2	1.5	1.5	0
TRANSPORTING	ASSY	5.000	1	7	2	10.0	1.5	33
LIFTING	ASSY	5.000	1	7	2	10.0	1.5	33
10 SURFACE PREP								
BLASTING	SQ FT	.100	0	3	3	2.0	2.0	0
GRINDING	FOOT	.200	0	3	3	2.0	2.0	0
11 COATING	SQ FT	.100	40	7	3	10.0	2.0	20
12 TESTING								
DYE PENETRANT	FOOT	.250	0	2	2	1.5	1.5	0
AUDIOGAGE	FOOT	.500	0	2	2	1.5	1.5	0
X RAY	FOOT	.500	0	2	2	1.5	1.5	0

TOTAL TRADE MANHOURS	394
TRADE SUPPORT MANHOURS (35% OF TRADE MANHOURS)	138
TOTAL PRODUCTION MANHOURS	532
LABOR COST (MANHOURS X MNHR COST $20.00	$10639
MATERIAL COST (FROM MATERIAL SCHEDULE)	750
TOTAL COST	$11389

Figure 2-2

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Chapter 3- RELATIVE PRODUCIBILITY EVALUATION

GENERAL

This chapter describes the use of the two programs which are used to determine and record the relative producibility of various design alternatives. The programs are contained in the PROD directory of the floppy disk which accompanies this manual. One of the programs is written in GW-BASIC and stored in the subdirectory PROD\BASPROG, and the other is in spreadsheet format and stored in the PROD\SPRDPROG subdirectory.

The producibility criteria used in these programs are those which were determined during the research described in reference 1. The spreadsheet program described in this chapter also uses the producibility criteria weighting factors that were obtained during that research effort Chapter 4 provides detailed instructions for operation of the computer programs used to determine those weighting factors and to reevaluate them when necessary.

PRELIMINARY

The first program to be used for evaluating the relative producibility of two or three design alternatives is the GW-BASIC program If the GW-BASIC application program is not on your computer's hard disk it can be found on the main directory of the floppy disk provided with this manual. After selecting the directory or subdirectory where the GW-BASIC application program is located, enter GWBASIC. Where the "A" drive is indicated use "B" if appropriate.

Type LOAD" (or hit the F3 key) followed by A:\PROD\BASPROG\PRODC", and Enter. The initial screen of the program will then appear. Make sure your printer is on

If it is necessary to exit from the program prematurely, enter Ctd + C. This will place you back into the GW-BASIC screen To exit from GW-BASIC, enter SYSTEM.

INITIAL DATA INPUT

The first screen illustrated in Figure 3-1, asks for various data to be entered. Enter the name of the Project (normally the ship type or class designator, such as DDGX), and then the name of the design variant that is being evaluated. Next you will be asked to provide titles for each of up to three alternative designs for this variant that are to be evaluated for their relative producibility. If there are three alternatives, you will be asked to set a limit for the consistency ratio or to accept the default value of 0.2. For only two alternatives, the consistency of evaluations is always perfect giving a consistency ratio value of 0.0, so you will not be asked to select this value when only two alternatives are being considered.

Figure 3.1 illustrates what this screen looks like when all of the questions on it have been answered and before the Enter key is pressed after entering the desired consistency ratio value. The Project name, design variant descriptor and the names of the three alternatives chosen for this illustration are "TEST", "STRUCTVAR.", "NEW WAY", "LAST WAY' and "OLD WAY", respectively. The value of the consistency ratio has been changed to 0.25, primarily for purposes of illustration

EVALUATOR INPUT

The screens that next appear record an individual evaluator's assessments of the relative producibility of the different design alternatives being considered. After entering the name and organization of the evaluator, you will be presented with a table which lists the 10 higher level producibility criteria which may be evaluated. This screen appears as shown in Figure 3.2.

```
Enter the Project or Ship Type Identifier                          : TEST
Enter the design change being evaluated                            : STRUCT VAR
Enter a TITLE for Alternative 1 (8 letters or less)                : NEW WAY
Enter a TITLE for Alternative 2 (8 letters or less)                : LAST WAY
Now name Alternative 3 (8 letters) or press ENTER to bypass        : OLD WAY
The Alternatives you have chosen are listed below:

        Alternative 1 is     NEW WAY
        Alternative 2 is     LAST WAY
        Alternative 3 is     OLD WAY

Are these Alternatives Correct? (<Y>/N) :

The data to be entered will be rejected if the data is found to be
    excessively inconsistent.  The limit currently set for the
    consistency factor is .2 .  To modify this limit, enter Y now.
    Any other entry will leave the limit it at .2                  : Y

Enter your choice for the consistency factor limit                 : .25
```

Figure 3-1

After you select one of these, by entering a number between 1 and 10, the program lists all of the subcriteria used to evaluate that particular choice, as shown in Figure3-3. You will then be led through all of the steps necessary to determine the weighting to be applied to each design alternative for any or all of those subcriteria. Once thesec omparisons have been completed, you can select another of the lO criteria shown in Figure 3.2 and repeat the process for the subcriteria related to that choice.

As illustrated in Figure 3.3, after listing the subcriteria of the chosen criterion the program asks whether each, some or only of the subcriteria will be evaluated. For each subcriterion, you will be asked whether you will use hard data. Hard data is actual quantitative information such as the number of feet of welding the number of pipe bends, etc. When quantitative information is available, it should be used. In some cases of hard data such as feet of weld larger quantities lead to additional manhours, thus to lower producibility. In other cases, such as component packaging larger quantities yield higher producibility. Whenever hard data is to be entered, the program indicates whether higher values or lower values will be considered the more highly producible.

Figure 3-3 illustrates the results of entering 300,400 and 500 as the values for material cost The opportunity to change values is always provided. After you have entered values with which you are satisfied, the program will display the weighted values for each of the design alternatives, as shown at the bottom of Figure 3.3.

If hard data is not available, the program will lead you through a series of comparisons of each of the design alternatives, asking which of the two is superior from a producibility standpoint with respect to the subcriterion being evaluated. Figure 3.4 illustrates the steps of this process.

```
Enter Name of Evaluator : A PERSON
Enter Evaluator's Organization: A COMPANY

************************ Criterion Code List *************************
Code          Label                                Number of Sub-Criteria
 1      ARRANGEMENT                                          4
 2      SIMPLICITY                                           5
 3      MATERIAL                                             2
 4      STANDARDIZATION                                      6
 5      Welding                                              6
 6      Sheetmetal                                           2
 7      Machining                                            3
 8      Pipefitting                                          6
 9      Electrical/Elex                                      4
10      HVAC                                                 6
Enter Criterion Code to be Evaluated: 3
```

Figure 3-2

```
Here are the MATERIAL SUBCRITERIA:
(1) MATERIAL COSTS
(2) WASTEAGE FACTOR

WILL YOU EVALUATE EACH (E), SOME (<S>) OR ONE (1) OF THESE?  : E
WILL YOU USE HARD DATA FOR ANY OF THESE COMPARISONS? (Y,<n>) :Y
FOR CRITERION (1) MATERIAL COSTS
WILL YOU USE HARD DATA? (Y,<n>)   : Y

 HE SURE TO USE SMALLER VALUE FOR SUPERIOR CHOICE
ZERO AND NEGATIVE VALUES ARE NOT PERMITTED
ENTER VALUE FOR NEW WAY                              : 300

ENTER VALUE FOR LAST WAY                             : 400

ENTER VALUE FOR OLD WAY                              : 500
WANT TO CHANGE ANY OF THE VALUES? (Y,<N>) : N
JUDGMENTS ARE:
          FOR: (1) NATERIAL COSTS
               NEW WAY =                                      0.4255
               LAST WAY =                                     0.3191
               OLD WAY =                                      0.2553
                    Consistency Ratio = 0.0000
                    Lambda Max =         3.0000
TO CONTINUE, Press <Y>
```

Figure 3-3

The alternative "New Way" was considered to be the superior choice, so" 1" was entered. The programmer next asks for the factor of superiority. The value 3 was entered indicating that''New Way'' is considered three times as good as ''Last Way'' with respect to Wastea-ge Factor. The process continues, comparing each design alternative against each other design alternative.

```
FOR CRITERION (2) WASTEAGE FACTOR
WILL YOU USE HARD DATA? (Y, <N>)   :N

IS ( 1 ) NEW WAY OR ( 2 ) LAST WAY SUPERIOR?                    :1
FACTOR OF SUPERIORITY?   MUST BE 1 (EQUAL) OR GREATER           :3
WANT TO CHANGE EITHER VALUE? (Y/<N>):

IS(1) NEW WAY OR(3)OLD WAY SUPERIOR?                            :1
FACTOR OF SUPERIORITY?   MUST BE 1 (EQUAL) OR GREATER           :5
WANT TO CHANGE EITHER VALUE? (Y/<N>) :

IS(2) LAST WAY OR(3)OLD WAY SUPERIOR?                           :2
FACTOR OF SUPERIORITY?   MUST BE 1 (EQUAL) OR GREATER           :2
WANT TO CHANGE EITHER VALUE? (Y/<=):

ARE ALL THE  ENTRIES CORRECT? (<Y>/N) :

JUDGEMENT ARE:
        FOR: (2] WASTEAGE FACTOR
             NEW WAY=                                   0.6483
             LAST WAY =                                 0.2297
             OLD WAY=                                   0.1220
                  Consistency RATIO = 0.0032
                  Lambda Max=         3.0037
```

Figure 3-4

Following the entry of the data, the weighting factor for each of the design alternatives is calculated and printed out on the screen Note that the consistency ratio for these entries was greater than zero, but less than 0.25, so the data was accepted. (The data is slightIy inconsistent since, if(1) is three times as good as (2) and five times as good as (3), (2) should be 1.67 times as good as (3), rather than twice as good.) If the data is too inconsistent you will be given the opportunity to reevaluate the alternatives; otherwise the data will not be printed out.

After all of the producibility criteria for which the design alternatives are considered to have different relative values have been assessed by one evaluator, the data for another evaluator can be entered. When there are no more evaluations to be made, the program ends. Entering SYSTEM takes you out of the GW-BASIC application program and returns you to the screen from which you began.

PRINTED REPORTS

As you enter data and the computer- carries out its calculations, information is sent to the printer buffer. Whenever a complete page of data is entered the printer will print out a page without any action on your part At the end of the session when you indicate that there are no more evaluations to be made, the last page will be printed.

Figure 3.5 illustrates the format of the printed reports which the program generates. This figure docurnents the data entered in the screens pictured in Figures 3.1 through 3.4. Having all of the entered data recorded in addition to the final weighting factors, allows review of the data that was entere~ in order to resolve any apparent discrepancies in the resulting weighting factor values.

PRODUCIBILITY CRITERIA EVALUATION of Design Alternatives for TEST Program
Design Variant: STRUCT VAR Consistency Ratio Limit = 0.2500

Evaluation by A PERSON of A COMPANY

MATERIAL Subcriteria Weighting Evaluation

SUBCRITERIA	DESIGN ALTERNATIVES NEW WAY	LAST WAY	OLD WAY	CRATIO
(1) MATERIAL COSTS Data	300.00	400.00	500.00	
MATERIAL (1) MATERIAL COSTS Weights	0.4255	0.3191	0.2553	0.0000
(2) WASTEAGE FACTOR Data				
ALTS	DOMINANT ALT	SUP FACTOR		
(1) NEW WAY Vs (2) LAST WAY		3.00		
(1) NEW WAY VS (3) OLD WAY	1	5.00		
(2) LAST WAY VS (3) OLD WAY	2	2.00		
MATERIAL (2) WASTEAGE FACTOR Weights	0.6483	0.2297	0.1220	0.0032

Figure 3-5

RESOLVING EVALUATOR DATA DIFFERENCES

Preferably, each design change should be evaluated by several knowledgeable persons, to obtain as broad an assessment as possible. Where the results of various evaluators are significantly different attempts should be made to resolve the differences before going further. Since each evaluator's choices are recorded on hard copy print outs, it is simple to identify where the evaluators' differences are. The program can be reused as often as desired for any reevaluations based on changes to evaluators' data. Since the data is not recorded in the computer's files, no problem is created by reentering additional, different data by or from any of the evaluators.

SPREADSHEETS

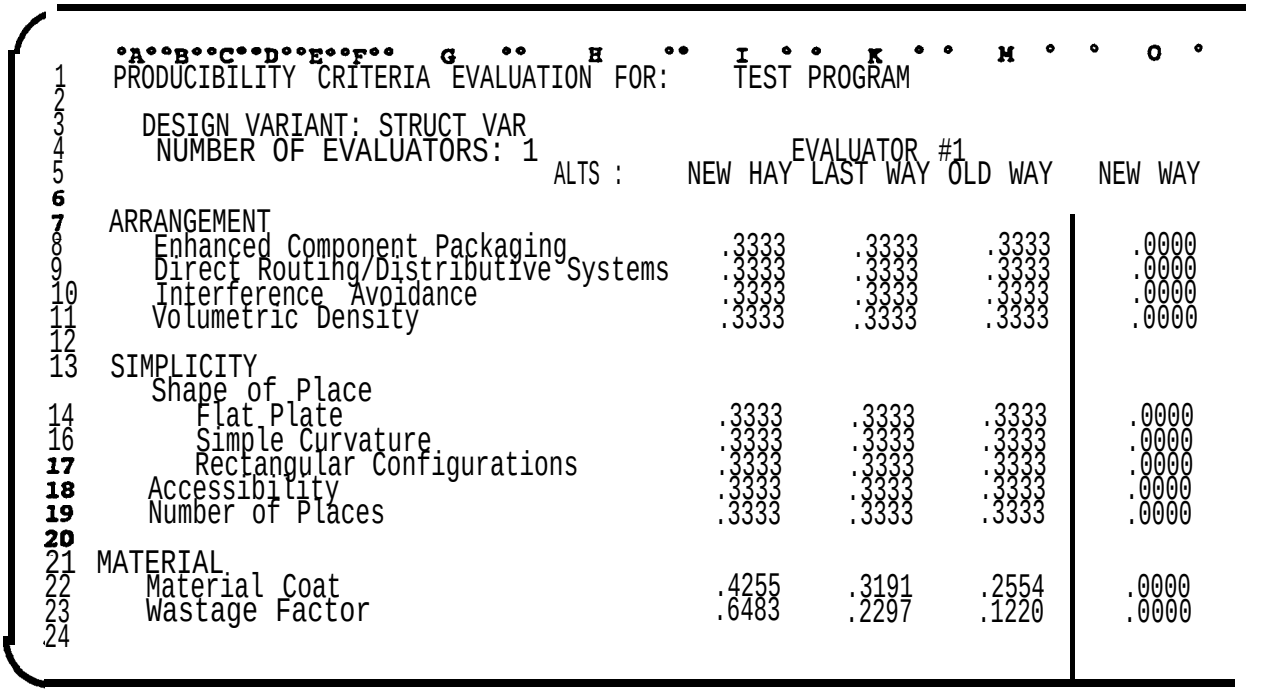
After the data from all of the evaluators has been obtained an average weighting factor for each design alternative must be calculated for each subcriterion that was evaluated. This is done using the spreadsheet program

After going into your spreadsheet application programrm load the file

A:\PROD\SPRDPROG\WATEFORM.XXX,

where the "A" should be replaced by whatever drive the floppy is actually in and the ".XXX" must be replaced with the file extension that applies to your application program; ".WK1" for LOTUS 123, for instance. Figure 3.6 shows how the initial screen will appear after some initial information has been entered.. Many of the fields of the spreadsheet are "protected", since there is no need to enter any data in those fields. Protected fields are indicated on the actual screens by color coding

Enter the name of the project and that of the design variant in their respective fields. Then enter the number of evaluators. The form provided allows for the data for up to six evaluators. If the alternatives are compared by more than six evaluators, the form will have to modified by adding additional column.



	A	B	C	D	E	F	G	H	I	K	M	O
1	PRODUCIBILITY CRITERIA EVALUATION FOR: TEST PROGRAM											
2												
3	DESIGN VARIANT: STRUCT VAR											
4	NUMBER OF EVALUATORS: 1								EVALUATOR #1			
5							ALTS :		NEW HAY	LAST WAY	OLD WAY	NEW WAY
6												
7	ARRANGEMENT											
8	Enhanced Component Packaging								.3333	.3333	.3333	.0000
9	Direct Routing/Distributive Systems								.3333	.3333	.3333	.0000
10	Interference Avoidance								.3333	.3333	.3333	.0000
11	Volumetric Density								.3333	.3333	.3333	.0000
12												
13	SIMPLICITY											
	Shape of Place											
14	Flat Plate								.3333	.3333	.3333	.0000
16	Simple Curvature								.3333	.3333	.3333	.0000
17	Rectangular Configurations								.3333	.3333	.3333	.0000
18	Accessibility								.3333	.3333	.3333	.0000
19	Number of Places								.3333	.3333	.3333	.0000
20												
21	MATERIAL											
22	Material Coat								.4255	.3191	.2554	.0000
23	Wastage Factor								.6483	.2297	.1220	.0000
24												

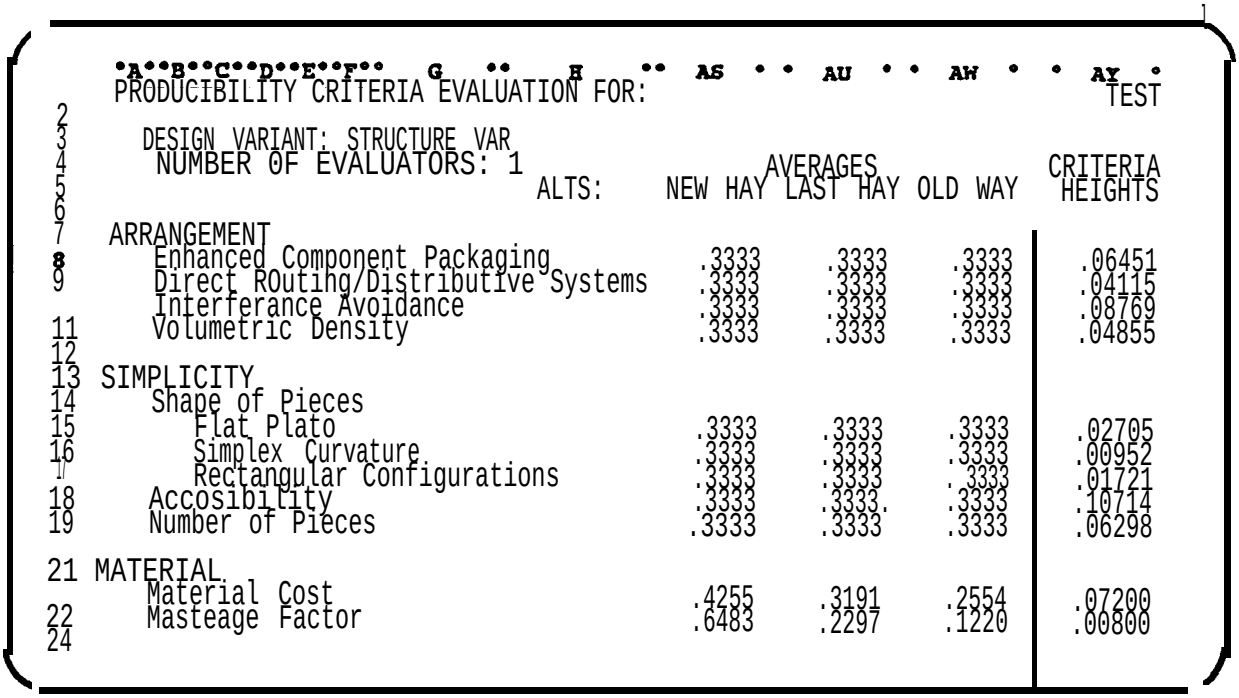
Figure 3-6

Enter the name of the first evaluator in the space identified as "Evaluator #1" Three columns are provided for the data from each evaluator,one column for each of the up-to three alternatives being compared. Enter the title for each of the design variant alternatives in the cells at the head of the three columns under the first evaluator. Important: If there are only two alternatives being considered the field for the third one must be filled as a blank The titles of the desigr variant alternatives need only be entered once. The computer program will automatically use the same titles in the appropriate columns of the rest of the form

When the titles of the alternatives have been entered enter the command to carry out calculation (F9 for LOTUS 123) The rows for each oriterion will be automatically filled with the appropriate values for equally weighting each alternative. Thus, if there are three alternatives named the relative weight for each of them will appear initially as .3333, while if there are onIy two, the relative weights will be .5000 for alternatives 1 and 2 and .0000 for alternative 3.

These values will appear in the respective columns for only as many evaluators as were indicated in the number-of evaluators field. That is, if you have entered the number 2 as the number of evaluators, all fields in the columns for evaluators 3 through 6 will remain as zero. Notice in Figure 3-6 that the values in the last column to the right are all zero. This is the first column for the second evaluator. Since the number of evaluator has been indicated as 1, only the columns for evaluator #l have been filled in with non-zero values.

Proceed to enter the weighting values for each evaluator from the printout obtained from the GW-BASIC pro-Figure 3-5. It will only be necessary to enter data for those criteria in which the alternative designs have differing weighting factors. Further, if there are just two alternatives, the values for only one of the alternatives will need to be enters since the other value will be calculated automatically, their sum having to equal unity. Similarly, in the case of three alternatives, only two of the three values need be entered for any criterion .In fact the third column of each evaluator is protected to preclude incorrect values from being entered.



```
    ••A••B••C••D••E••F••  G  ••   H   ••  AS  • •  AU  • •  AW  • •  AY  •
    PRODUCIBILITY CRITERIA EVALUATION FOR:                              TEST
2
3     DESIGN VARIANT: STRUCTURE VAR
4      NUMBER 0F EVALUATORS: 1                    AVERAGES              CRITERIA
5                                ALTS:    NEW HAY  LAST HAY  OLD WAY   HEIGHTS
6
7   ARRANGEMENT
8      Enhanced Component Packaging          .3333     .3333     .3333    .06451
9      Direct ROuting/Distributive Systems   .3333     .3333     .3333    .04115
       Interferance Avoidance                .3333     .3333     .3333    .08769
11     Volumetric Density                    .3333     .3333     .3333    .04855
12
13  SIMPLICITY
14     Shape of Pieces
15        Flat Plato                         .3333     .3333     .3333    .02705
16        Simplex Curvature                  .3333     .3333     .3333    .00952
17        Rectangular Configurations         .3333     .3333     .3333    .01721
18     Accosibility                          .3333     .3333.    .3333    .10714
19     Number of Pieces                     .3333     .3333     .3333    .06298

21  MATERIAL
       Material Cost                         .4255     .3191     .2554    .07200
22     Masteage Factor                       .6483     .2297     .1220    .00800
24
```

Figure 3-7

If there are more evalluators than one,then,after the data from the first evaluator is enterd,shift over to the columns for the second evaluator and enter those data. Continue until the data from all evaluators have been entered. Then again initiate calculation The program will calculate the average values of all the evaluators' data, which will appear in columns AS, AU and AW, as shown in Figure 3-7. Since only one evaluator was used in this example, the values shown in Figure 3-7 are, of course, the same as those for evaluator #1 in Figure 3-6.

The criteria weighting values are shown in column AY. These values already will have been determined and entered into the spreadsheet form as described in the following Chapter.

If you then move the cursor to the right until columns AY through BE are visible on the screen the information shown in Figure 3-8 will be displayed. Columns BL BC and BE contain the product of the values in column AY and the values in columns AS, AU and AW, respectively, shown in Figure 3-7.

After all of the data has been entered and the Recalculate keys pressed move the cursor so that the values infields BA80 through BE82 can be seen These fields, illustrated in Figure 3.9, give the final overall weighted relative producibility factors. The alternative with the largest value in fields BA81 to BE81 will be the most producible alternative. However, as expained in Reference 1, these values are relative only in the qualitative sense, so that the largest value merely identifies the most producible design alternative. The values DO NOT indicate the quantitative relative cost of the alternatives.

Save the filled in worksheet to a file with a title other than WATEFORM so that the WATEFORM file will always be available for evaluating other design variants.

Print out the results for fixture reference and exit from the program.

```
    °A°°B°°C°°D°°E°°F°°   G   °°    H    °° AY  °  °  BA  °  °  BC  °  °  BE  °
1   PRODUCIBILITY CRITERIA EVALUATION FOR:    TEST  PROGRAM
2
3     DESIGN VARIANT: STRUCT VAR
4      NUMBER OF EVALUATORS:    1          CRITERIA |------ Final Weights -----|
5                                ALTS:     WEIGHTS  NEW WAY LAST WAY  OLD WAY
6
7   ARRANGEMENT
8      Enhanced Component Packaging          .06451   .0215    .0215     .0215
9      Direct Routing/Distributive Systems   .04115   .0137    .0137     .0137
10     Interference Avoidance                .08769   .0292    .0292     .0292
11     Volumetric Density                    .04855   .0162    .0162     .0162
12
13  SIMPLICITY
14     Shape of Pieces
15        Flat Plate                         .02705   .0090    .0090     .0090
16        Simple Curvature                   .00952   .0032    .0032     .0032
17        Rectangular Configurations         .01721   .0057    .0057     .0057
18     Accessibility                         .10714   .0357    .0357     .0357
19     Number of Pieces                      .06298   .0210    .0210     .0210
20
21  MATERIAL
22     Material Cost                         .07200   .0306    .0230     .0184
23     Wasteage Factor                       .00800   .0052    .0018     .0010
24
```

Figure 3-8

```
    °A°°B°°C°°D°°E°°F°°   G   °°    H    °° AY  °  °  BA  °  °  BC  °  °  BE  °
1   PRODUCIBILITY CRITERIA EVALUATION FOR:    TEST  PROGRAM
2
3     DESIGN VARIANT: STRUCT VAR
4      NUMBER OF EVALUATORS:    1          CRITERIA |------ Final Weights -----|
5                                ALTS:     WEIGHTS  NEW WAY LAST WAY  OLD WAY
68           Cable Length                    .00641   .0021    .0021     .0021
69           Cable Size                      .00653   .0022    .0022     .0022
70        Connections/Hookups                .02100   .0070    .0070     .0070
71        Wireways                           .01661   .0055    .0055     .0055
72     HVAC Considerations
73        HVAC Ducting
74           Size                            .00320   .0011    .0011     .0011
75           Length                          .00324   .0011    .0011     .0011
76           Material Type                   .00291   .0010    .0010     .0010
77           Configuration Changes           .00714   .0024    .0024     .0024
78        Equipment Installation             .01439   .0048    .0048     .0048
79        HVAC Insulation                    .01022   .0034    .0034     .0034
80                                           -------  -----    ------    -------
81              Producibility Evaluation:    1.00016   .3425    .3315     .3261
82                                                   NEW WAY LAST WAY  OLD WAY
```

Figure 3-9

Chapter 4 - DETERMINING PRODUCIBILITY CRITERIA WEIGHTING FACTORS

GENERAL

The producibility subcriteria weighting factors that were used to multiply each of the design alternative weighting factors in the spreadsheet described in Chapter 3, and shown in the center column of figures in Figure 3-7, are determined by pairwise comparisons using the AHP technique. The values of these producibility weighting factors need be determined only once for each project, since they are dependent primarily on the construction process rather than the mission of the ship. Once determined, they are entered into the spreadsheet WATEFORM and used for the producibility analysis of the alternatives for each design variant studied.

It is also not likely that these values will change significantly for different types of ship. However, should it be found necessary or desirable to do so, the programs described in this chapter would be used to determine new values

The two programs for determining these factors are written in GW-BASIC, and are run using the GW-BASIC application program. The first of these programs, PRODA is used for recording the evaluations of individuals who are knowledgeable of the relative importance of the various producibility evaluation criteria to be used. The evaluations of the individuals may be obtained through the use of questionnaires and the results recorded in this program by an operator or they may be determined through an individual's direct use of the computer program. Each evaluator's responses are printed out as the program proceeds, providing a permanent record that may be studied separately.

The second program, PRODB, is used to obtain the normalized geometric mean of the values obtained from all of the individuals. This program is more likely to be run by a single operator once, after all the individual responses have been obtained. Again a printed report is generated as this program is run showing each individual's responses for a given criterion and the mean of all of the responses for that criterion.

The line item statements for each of these programs are listed in the Appendix.

RECORDING INDIVIDUAL EVALUATIONS

The first program is in the file named PRODA in subdirectory BASPROG in the PROD directory. After starting the GW-BASIC program at the start-up screen enter (using B: instead of A if appropriate)

```
LOAD"A:\PROD\BASPROG\PRODA",R
```

The initial screen for this program asks for the name of the project, the value to be used for the consistency ratio, the evaluator's name and organization. See Figure 4-1.

The next screen shown in Figure 4-2, lists all of the levels of the criteria/subcriteria tree. At the bottom of the screen, enter the number, listed under the title "Code", of the criteria which you will evaluate. In Figure 4-2, the number 3, corresponding to the criterion "SIMPLICITY", has been entered.

```
Enter the Project or Ship Type Identifier     : TEST

The data to be entered will be rejected if the data is found to be
    excessively inconsistent.  The limit currently set for the
    consistency factor is  .2 .  To modify this limit,
    enter Y now.  Any other entry will leave the limit at  .2    :  Y

Enter your choice for the consistency factor limit : .25

Enter Evaluator's Name :              A PERSON

Enter Evaluator's Organization:       A COMPANY
```

Figure 4-1

```
***** Enter Criterion Code from List *****
Code          Label                                Number of Sub-Criteria
 1    PRODUCIBILITY PARAMETERS                                  5
 2      ARRANGEMENT                                             4
 3      SIMPLICITY                                              3
 4        Shape of Pieces                                       3
 5      MATERIAL                                                2
 6      STANDARDIZATION                                         2
 7        Component Standardization                             3
 8          Structural Components                               3
 9      FABRICATION/ASSEMBLY                                    6
10        Welding                                               2
11          Welding Process                                     3
12          Welding Configuration                               3
13            Fillet Configuration                              2
14        Sheetmetal                                            2
15        Machining                                             3
16        Pipefitting                                           5
17          Pipefitting Process                                 2
18        Electrical/Elex                                       3
19          Cable Length/Size                                   2
20        HVAC                                                  3
21          HVAC Ducting                                        4
Enter Criterion Code to be Evaluated:  3
```

Figure 4-2

```
Here are the SIMPLICITY SubCriteria:
(1) SHAPE OF PIECES
(2) ACCESSIBILITY
(3) NUMBER OF PIECES

                        FOR COMPARISON OF
(1) SHAPE OF PIECES              WITH (2) ACCESSIBILITY
WHICH HAS GRBATER EFFECT ON MINIMIZING MANHOURS/COST? ( 1 OR 2 ) : 2
BY WHAT FACTOR? Must Be 1 (Equal) or Greater.                    : 3
WANT TO CHANGE EITHER VALUE? (Y/<N>): N

                        FOR COMPARISON OF
(1) SHAPE OF PIECES              WITH (3) NUMBER OF PIECES
WHICH HAS GREATER EFFECT ON MINIMIZING MANHOURS/COST? ( 1 OR 3 ) :
BY WHAT FACTOR? Must Be 1 (Equal) or Greater.                    : 2
WANT TO CHANGE EITHER VALUE? (Y/<N>):

                        FOR COMPARISON OF
(2) ACCESSIBILITY                WITH (3) NUMBER OF PIECES
WHICH HAS GREATER EFFECT ON MINIMIZING MANHOURS/COST? ( 2 OR 3 ) : 2
BY WHAT FACTOR? Must Be 1 (Equal) or Greater.                    : 5
WANT TO CHANGE EITHER VALUE? (Y/<N>):

ARE ALL THE ENTRIES CORRECT? (<Y>/N):
```

Figure 4-3

Upon entering the choice of Code, yop will be presented with another screen, which first identifies the subcriteria that must reevaluated, as shown inFigure 4-3, and asks for an evaluation of the first pair of those. The program leads you through the evaluation of each pair of the subcriteria. As each question is answered, another question is askedoran opportunity for verification is given. The program leads you throughthe steps necessary to identify which one, of ach pair of subcriteria, is considered to have the greater influence in minimizing construction manhours/cost and then to identfy the factor by which that subcriterion is superior to the other.

A superiorly factor of 1 indicates that the two elements are equal from a producibility standpoint, whereas a factor of 2 indicates that the superior element is twice as good as the other.

After all of the subcriteria of the selected Criterion Code have been compared with each of the others, the program computes a consistency ratio, as shown in Figure 4-4. When only two subcriteria are involved, the value of this ratio will always be zero. However, when more than two are compared, the ratio probably will be other than zero. For instance, in the case of the data presented in Figure 4-3, the consistency ratio is greater than zero. This is because the superiority factor of (2) Accessibility, compared to (3) Number of Pieces, should be 6 (instead of 5) in order to be perfectly consistent with the factors used in the two preceding comparisons.

If the value of the ratio is acceptable, i.e., is less than the level identified at the start of the program, the data will be recorded in a file in the A:\PROD\DATA subdirectory. Otherwise you will be given the option either to enter revised data for the same subcriteria until the data consistency is adequate or to start again on another set of subcriteria.

```
                          FOR COMPARISON OF
 (2) ACCESSIBILITY                  WITH (3) NUMBER OF PIECES
WHICH HAS GREATER EFFECT ON MINIMIZING MANHOURS/COST? ( 2 OR 3 ) : 2
BY WHAT FACTOR? Must Be 1 (Equal) or Greater.                      5
WANT TO CHANGE EITHER VALUE? (Y/<N>): N

ARE ALL THE ENTRIES CORRECT? (<Y>/N): Y
JUDGEMNTS ARE:
         For SIMPLICITY Subciteria:
              (1) SHAPE OF PIECES =                          0.2297
              (2) ACCESSIBIITY =                             0.6483
              (3) NUMBER OF PIECES =                         0.1220
                   consistency Ratio = 0.0032
                   LambdaMax=          3.0037

Producing Data File

Another Evaluation for the Same Person? (<Y>/N): N

Start a new person? (<Y>/N): N

Now exiting this program and closing the output data file.
Ok
```

Figure 4-4

The results of each evaluation are presented on the screen, as indicated inFigure 4-4. Data will be sent to the printer buffer as it is entered and calculated. A hard copy will be printe as a full sheet is filled or upon completion of data entry. Figure 4-5 illustrates the format of the printed reports.

After entering each set of responses you will be asked whether you want to enter data fc another set of subcriteria. The default response is yes and this response will cause Figure 4.2 to reappear. A negative response will allow you to choose to enter data for another evaluator or t quit the program. In Figure 4-4, both questions have been answered "No", in response to which the program will generate the printout of Figure 4-5 and end processing.

COMBINED WEIGHTING FACTORS

After all of the data from each of the individual evaluators has been entered into PRODA the mean values for each of the criteria levels can be determined through the use of PRODB. Enter

```
LOAD"  A:\PROD\BASPROG\PRODB",R
```

After entering the name of the project, you will be presented with the list of criteria, Fig- ure 4-6, which is the same as shown in Figure 4-2 except for the instruction at the bottom of th screen.

To obtain the weighting factors for a single level of the criteria tree, enter the number of the criterion of interest. To obtain the values for all of the levels of the project's criteria tree, enter 99 as the Code.

```
PRODUCIBILITY CRITERIA Weighting Evaluation for TEST Project
        Consistency Ratio Limit =  0.2500

  Evaluation by  A PERSON  of  A COMPANY

SIMPLICITY Subcriteria Pairs                              DOMINANT ONE,  FACTOR
(1) SHAPE OF PIECES VS (2) ACCESSIBILITY                              2    3.00
(1) SHAPE OF PIECES VS (3) NUMBER OF PIECES                           1    2.00
(2) ACCESSIBILITY VS (3) NUMBER OF PIECES                             2    5.00

 Resulting SIMPLICITY SubCriteria Weighting Factors:
          (1) SHAPE OF PIECES =                          0.2297
          (2) ACCESSIBILITY =                            0.6483
          (3) NUMBER OF PIECES =                         0.1220
              Consistency Ratio =          0.0032
              Lambda Max =                 3.0037
*****************************************************************************
```

Figure 4-5

```
        Code      Title                              Number of Sub-Criteria
          1   PRODUCIBILITY PARAMETERS                          5
          2     ARRANGEMENT                                     4
          3     SIMPLICITY                                      3
          4       Shape of Pieces                               3
          5     MATERIAL                                        2
          6     STANDARDIZATION                                 2
          7       Component Standardization                     3
          8         Structural Components                       3
          9     FABRICATION/ASSEMBLY                            6
         10       Welding                                       2
         11         Welding Process                             3
         12         Welding Configuration                       3
         13           Fillet Configuration                      2
         14       Sheetmetal                                    2
         15       Machining                                     3
         16       Pipefitting                                   5
         17         Pipefitting Process                         2
         18       Electrical/Elex                               3
         19         Cable Length/Size                           2
         20       HVAC                                          3
         21         HVAC Ducting                                4
 Enter 99 to Generate Mean Values for All Criteria, or
 Enter Code Number of Criterion to be Evaluated          :  3
```

Figure 4-6

```
For SIMPLICITY Subcriteria Weights,

 There were  5  Evaluators. The Geometric Means of their responses are:

(1) SHAPE OF PIECES      Value =                                  0.2013
(2) ACCESSIBILITY        Value =                                  0.4512
(3) NUMBER OF PIECES     Value =                                  0.3475

The Geometric Mean of Lambda Max Total =  3.0230


Evaluate more Criteria for the same Project? (<Y>/N): N
Want To Evaluate Criteria for another Project? (Y/<N>):  N
Ok
```

Figure 4-7

Figure 4-7 illustrates the result of having entered the value 3, to obtain the SIMPLICITY subcriteria weightingfactors. The screen shows the number of evaIuators for the selected criterion in addition to the final normalized geometric mean values of those evaluators' data.

When the value of 99 is entered, the screen will not show any results except a message that the values are being printed.

A printout will be provided, showing the names of each evaluator and their input data as well as the mean values, as shown in Figure 4-8.

When you have finished, enter SYSTEM to leave GW-BASIC.

PREPARING WATEFORM

The next step is to enter the weighting factors for each of the subcriteria, as generated from the PRODB program into the appropriate columns of the spreadsheet WATEFORM.XXX found in the PROD\SPRDPROG subdirectory. The rightmost columns of this form contain the formulas necessary to calculate the final values that ultimately are applied to the individual design alternative weighting values. These columns must be "unprotected" before new values can be entered into the cells. Figure 4-9 is a printout of the values that are provided in the form located on the disk provided with the manual. These values were determined by using the steps described in this chapter during the project described in Reference 1. A more complete description of the development and application of these values can be found in that document.

PRODUCIBILITY CRITERIA Weighting Factors for the TEST Project

Individuals' Weights for: SIMPLICITY SubCriteria are:

SOMEONE of COMPANY A		WEIGHT
(1) SHAPE OF PIECES		0.1684
(2) ACCESSIBILITY		0.4639
(3) NUMBER OF PIECES		0.3677
Consistency Ratio =	0.0891	
Lambda Max =	3.1034	

SOMEONEELSE of COMPANY B		WEIGHT
(1) SHAPE OF PIECES		0.1634
(2) ACCESSIBILITY		0.2970
(3) NUMBER OF PIECES		0.5396
Consistency Ratio =	0.0079	
Lambda Max =	3.0092	

YOUR NAME of YOUR CO		WEIGHT
(1) SHAPE OF PIECES		0.2000
(2) ACCESSIBILITY		0.4000
(3) NUMBER OF PIECES		0.4000
Consistency Ratio =	0.0000	
Lambda Max =	3.0000	

HIS NAME of HIS CO		WEIGHT
(1) SHAPE OF PIECES		0.2000
(2) ACCESSIBILITY		0.4000
(3) NUMBER OF PIECES		0.4000
Consistency Ratio =	0.0000	
Lambda Max =	3.0000	

A PERSON of A COMPANY		WEIGHT
(1) SHAPE OF PIECES		0.2297
(2) ACCESSIBILITY		0.6483
(3) NUMBER OF PIECES		0.1220
Consistency Ratio =	0.0032	
Lambda Max =	3.0037	

The total number of respondents = 5

The Normalized Geometric Mean of the above individual evaluations of SIMPLICITY SubCriteria Weights for the * TEST * project are :

	NGM
(1) SHAPE OF PIECES	0.2013
(2) ACCESSIBILITY	0.4512
(3) NUMBER OF PIECES	0.3475

The Geometric Mean of Lambda Max Total = 3.0230

****

Figure 4-8

PRODUCIBILITY CRITERIA EVALUATION FOR:

DESIGN VARIANT:STRUCT VAR
NUMBER OF EVALUATORS: 1

ALTS:	CRITERIA WEIGHTS	CRITERIA WEIGHTING CALCULATIONS LEVELS 1	2	3	4	5
ARRANGEMENT		.2419 .2419				
Enhanced Component Packaging	.0645	.0645	.2667			
Direct Routing/Distributive Systems	.0411	.0411	.1701			
Interference Avoidance	.0877	.0877	.3625			
Volumetric Density	.0485	.0485	.2007			
SIMPLICITY		.2239 .2239				
Shape of Pieces		.0538	.2402			
Flat Plate	.0271	.0271		.5030		
Simple Curvature	.0095	.0095		.1770		
Rectangular Configurations	.0172	.0172		.3200		
Accessibility	.1071	.1071	.4785			
Number of Pieces	.0630	.0630	.2813			
MATERIAL		.0800 .0800				
Material Cost	.0720	.0720	.9000			
Wasteage Factor	.0080	.0080	.1000			
STANDARDIZATION		.2220 .2220				
Component Standardization		.1416	.6380			
Structural Components		.0293		.2067		
Plate Thickness	.0071	.0071			.2621	
Shapes	.0139	.0139			.4732	
Sizes	.0083	.0083			.2847	
Outfitting Components	.0511	.0511		.3605		
Equipment Components	.0613	.0613		.4329		
Process Standardization	.0804	.0804	.3620			
FABRICATION AND ASSEMBLY		.2323 .2323				
Welding Considerations		.0295	.1271			
Welding Process		.0172		.5825		
Degree of Automation	.0088	.0088			.5099	
Position Optimization	.0037	.0037			.2179	
Heat Treatment	.0047	.0047			.2722	
Welding Configuration		.0123		.4175		
Fillet Configuration		.0041			.3345	
Edge Preparation	.0017	.0017				.4243
Number of Passes	.0024	.0024				.5857
Weld Length	.0033	.0033			.2648	
Weld Type	.0049	.0049			.4007	
Sheetmetal Consideration		.0141	.0609			
Configuration	.0063	.0063		.4427		
Process Required	.0079	.0079		.5573		
Machining Considerations		.0492	.2118			
Use of Common Foundations	.0150	.0150		.3054		
Mounting Details	.0144	.0144		.2926		
Installation	.0198	.0198		.4020		
Pipefitting Considerations		.0478	.2057			
Pipefitting Process		.0163		.3404		
Connection Type		.0072			.4456	
Welded	.0022	.0022				.3000
Brazed	.0014	.0014				.2000
Silver Soldered	.0007	.0007				.1000
Bolted	.0029	.0029				.4000
Use of Bends vice Fittings	.0090	.0090			.5544	
Pipe Size	.0063	.0063		.1312		
Pipe Length	.0061	.0061		.1286		
Pipe Material	.0081	.0081		.1698		
Piping Support Needs	.0110	.0110		.2300		
Electrical/Electronics Considerations		.0505	.2176			
Cable Used		.0129		.2560		
Cable Length	.0064	.0064			.4955	
Cable Size	.0065	.0065			.5045	
Connections/Hookups	.0210	.0210		.4154		
Wireways	.0166	.0166		.3286		
HVAC Considerations		.0411	.1769			
HVAC Ducting		.0165		.4013		
Size	.0032	.0032			.1943	
Length	.0032	.0032			.1962	
Material Type	.0029	.0029			.1765	
Configuration Changes	.0071	.0071			.4330	
Equipment Installation	.0144	.0144		.3501		
HVAC Insulation	.0102	.0102		.2486		
Producibility Evaluation:	1.0002	1.0001	5.0000	8.0001	6.0000	2.0100

Figure 4-9

Chapter 5 - DECISON MAKING AHP PROGRAMS

GENERAL

These programs are identical in concept to those used for evaluating the producibility of various design alternatives, except that producibility is only one of the criteria used for making the ultimate choice of which alternative is the best overall choice to be used in the design.

DECA, DECB and DECC are three programs written for GWBASIC, having the identical function and many virtually identical screens as PRODA, PRODB and PRODC, respectively. The primary difference is in the tree of criteria that is evaluated.

A significant consideration% however, is that the weighting factors for the elements of the decision making tree will vary considerably for different ship classes, rather than being essentially the same as in the case of producibility criteria weighting factors. They may in fact vary for different design stages of a single ship class. Thus, DECA and DECB will need to be run for each design stage of each project, with the results from DECB installed in the WATEFORM spreadsheet that is finally used to compare the various alternatives of each design variant studied in that design stage.

All of these programs are installed in the directory DEC. The BASIC programs are installed in subdirectory DEC\BASPROG, data from DECA is stored in DEC\DATA and the spreadsheet program used to average the information from each evaluator's use of DECC is WATEFORM stored in DEC/SRPRDPROG.

The BASIC statements used in DECA DECB and DECC are listed in the Appendix.

DECISION MAKING

Programs DECA and DECB need be accomplished only once for each ship type and design stage. They are the preliminaries to actually using program DECC for comparing the relative merits of with respect to any or all of the decision making subcriteria.

The process for using DECC is identical to that described in Chapter 3 for using PRODC.

The output from DECC is then entered into the spreadsheet WATEFORM found in the DEC\SPRDPROG subdirectory. The results will be found at the bottom of columns BE to BG, in the same way as shown in Figure 3-7 for the Producibility Evaluation..

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REFERENCES

1. Borchers, Kraine, Thompson, Wilkins, "Development of Producibility Evaluation Criteria", NSRP Report 0342; December, 1993
0405

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APPENDIX

NSRP PANEL SP-4

FILE: STRCTMS COST ESTIMATING FORM FOR STRUCTURAL WORK

PROJECT: "TITLE" MATERIAL: MS-STS

FILE : XYZ123.WK1 THICKNESS .375 INCHES

WORK PROCESS	WORK UNITS	PROCESS FACTOR (MNHRS/ WORK UNIT)	UNIT AMOUNT	ACTUAL STAGE	STANDARD STAGE	ACTUAL FACTOR	STANDARD FACTOR	MNHRS REQ'D
1 OBTAIN MATERIAL RECEIPT & PREP	SQ FT	.100	0	1	1	1.0	1.0	0
2 FLAME CUTTING								
AUTOMATIC	LN FT	.050	0	1	1	1.0	1.0	0
MANUAL	LN FT	.090	0	2	2	1.5	1.5	0
3 EDGE PREP-GRINDING								
FLAT	LN FT	.030	0	1	2	1.0	1.5	0
VERTICAL	LN FT	.050	0	2	2	1.5	1.5	0
OVERHEAD	LN FT	.070	0	2	2	1.5	1.5	0
4 SHAPING								
BREAK	BEND	.480	0	1	1	1.0	1.0	0
ROLLING	PIECE	1.200	0	1	1	1.0	1.0	0
LINE HEATING	PIECE	10.000	0	1	1	1.0	1.0	0
FURNACE	PIECE	15.000	0	1	1	1.0	1.0	0
PRESS	PIECE	.024	0	1	1	1.0	1.0	0
MACHINING	CU IN	.020	0	1	1	1.0	1.0	0
5 FIT UP & ASSEMBLY	JOINT	.560	0	2	2	1.5	1.5	0
6 WELDING, AUTO/MACHINE								
FILLET	LN FT	.054	0	2	2	1.5	1.5	0
BUTT	LN FT	na	0	2	2	1.5	1.5	0
7 WELDING, MANUAL								
FILLET								
DOWNHAND	LN FT	1.200	0	2	2	1.5	1.5	0
VERTICAL	LN FT	1.440	0	2	2	1.5	1.5	0
OVERHEAD	LN FT	1.680	0	2	2	1.5	1.5	0
BUTT								
DOWNHAND	LN FT	1.300	0	2	2	1.5	1.5	0
VERTICAL	LN FT	1.560	0	2	2	1.5	1.5	0
OVERHEAD	LN FT	1.820	0	2	2	1.5	1.5	0
8 MARKING	PIECE	.100	0	1	1	1.0	1.0	0
9 HANDLING								
STORAGE	PIECE	.100	0	2	2	1.5	1.5	0
TRANSPORTING	ASSY	5.000	0	3	3	2.0	2.0	0
LIFTING	ASSY	5.000	0	4	4	3.0	3.0	0

NSRP PANEL SP-4
FILE: STRCTMS

COST ESTIMATING FORM FOR STRUCTURAL WORK

PROJECT: "TITLE"
FILE : XYZ123.WK1

MATERIAL: MS-STS
THICKNESS .375 INCHES

WORK PROCESS	WORK UNITS	PROCESS FACTOR (MNHRS/ WORK UNIT)	UNIT AMOUNT	ACTUAL STAGE	STANDARD STAGE	ACTUAL FACTOR	STANDARD FACTOR	MNHRS REQ'D
10 SURFACE PREP								
BLASTING	SQ FT	.100	0	3	3	2.0	2.0	0
GRINDING	FOOT	.200	0	3	3	2.0	2.0	0
11 COATING	SQ FT	.100	0	3	3	2.0	2.0	0
12 TESTING								
DYE PENETRANT	FOOT	.250	0	2	2	1.5	1.5	0
AUDIOGAGE	FOOT	.500	0	2	2	1.5	1.5	0
X RAY	FOOT	.500	0	2	2	1.5	1.5	0

TOTAL TRADE MANHOURS		0
TRADE SUPPORT MANHOURS (35% OF TRADE MANHOURS)		0
TOTAL PRODUCTION MANHOURS		0
LABOR COST (MANHOURS X MNHR COST)	$20.00	$0
MATERIAL COST (FROM MATERIAL SCHEDULE)		$0
TOTAL COST		$0

NSRP PANEL SP-4
FILE: STRCTMS

COST ESTIMATING DATA FOR
STRUCTURAL WORK

MATERIAL: MS-STS

COST ESTIMATING PROCESS FACTORS

THICKNESS (INCHES)	1 FLAME CUTTING AUTO	2 FLAME CUTTING MANUAL	3 EDGE PREP GRINDING FLAT	4 EDGE PREP GRINDING VERTICAL	5 EDGE PREP GRINDING OVERHEAD	6 ASSEMBLY	7 WELDING-MACHINE FILLET	8 BUTT
0.250	0.05	0.09	0.02	0.04	0.06	0.56	0.04	na
0.375	0.05	0.09	0.03	0.05	0.07	0.56	0.05	na
0.500	0.05	0.09	0.04	0.06	0.08	0.56	0.07	0.48
0.750	0.07	0.12	0.06	0.12	0.17	0.56	0.08	0.58
1.000	0.07	0.16	0.08	0.17	0.26	0.56	0.09	0.70
1.250	0.08	0.17	0.12	0.21	0.30	0.56	0.11	0.85
1.500	0.10	0.18	0.17	0.26	0.34	0.56	0.13	1.02
2.000	0.12	0.23	0.17	0.26	0.34	0.56	0.16	1.22
3.000	0.15	0.26	0.26	0.34	0.43	0.56	0.19	1.47
4.000	0.16	0.28	0.31	0.41	0.52	0.56	0.23	1.76
5.000	0.17	0.32	0.37	0.49	0.62	0.56	0.28	2.12

THICKNESS (INCHES)	1 WELDING-MANUAL FILLET DOWN	2 VERT	3 OVHD	4 WELDING-MANUAL BUTT DOWN	VERT	OVHD	7 THICKNESS FACTOR	8 POSTION VERT	9 FACTORs OVHD
0.250	0.12	0.24	0.36	0.62	1.24	1.86	1.00	2.00	3.00
0.375	0.23	0.38	0.54	1.00	1.67	2.33	1.20	1.67	2.33
0.500	0.34	0.51	0.68	1.30	1.95	2.60	1.20	1.50	2.00
0.750	0.60	1.20	1.70	1.80	3.60	5.10	1.20	2.00	2.83
1.000	1.00	2.13	3.25	2.40	5.10	7.80	1.20	2.13	3.25
1.250	1.20	2.10	3.00	3.20	5.60	8.00	1.20	1.75	2.50
1.500	1.44	2.20	2.88	3.80	5.81	7.60	1.20	1.53	2.00
2.000	1.73	2.64	3.46	5.10	7.80	10.20	1.20	1.53	2.00
3.000	2.07	2.71	3.43	6.12	8.00	10.12	1.20	1.31	1.65
4.000	2.49	3.25	4.12	7.34	9.60	12.15	1.20	1.31	1.65
5.000	2.99	3.90	4.94	8.81	11.52	14.58	1.20	1.31	1.65

NSRP PANEL SP-4
FILE: STRTHY80

COST ESTIMATING DATA FOR
STRUCTURAL WORK

MATERIAL: HY80

COST ESTIMATING PROCESS FACTORS

THICKNESS (INCHES)	1 FLAME CUTTING AUTO	2 FLAME CUTTING MANUAL	3 EDGE PREP GRINDING FLAT	4 EDGE PREP GRINDING VERTICAL	5 EDGE PREP GRINDING OVERHEAD	6 ASSEMBLY	7 WELDING-MACHINE FILLET	8 BUTT
0.250	0.05	0.09	0.02	0.04	0.06	0.56	0.04	na
0.375	0.05	0.09	0.03	0.05	0.07	0.56	0.05	na
0.500	0.05	0.09	0.04	0.06	0.08	0.56	0.07	0.48
0.750	0.07	0.12	0.06	0.12	0.17	0.56	0.08	0.58
1.000	0.07	0.16	0.08	0.17	0.26	0.56	0.09	0.70
1.250	0.08	0.17	0.12	0.21	0.30	0.56	0.11	0.85
1.500	0.10	0.18	0.17	0.26	0.34	0.56	0.13	1.02
2.000	0.12	0.23	0.17	0.26	0.34	0.56	0.16	1.22
3.000	0.15	0.26	0.26	0.34	0.43	0.56	0.19	1.47
4.000	0.16	0.28	0.31	0.41	0.52	0.56	0.23	1.76
5.000	0.17	0.32	0.37	0.49	0.62	0.56	0.28	2.12

THICKNESS (INCHES)	1 WELDING-MANUAL FILLET DOWN	2 FILLET VERT	3 OVHD	4 WELDING-MANUAL BUTT DOWN	BUTT VERT	6 OVHD	7 THICKNESS FACTOR	8 POSTION VERT	FACTOI OVH
0.250	0.12	0.24	0.36	0.62	1.24	1.86	1.00	2.00	3.0
0.375	0.23	0.38	0.54	1.00	1.67	2.33	1.20	1.67	2.3
0.500	0.34	0.51	0.68	1.30	1.95	2.60	1.20	1.50	2.0
0.750	0.60	1.20	1.70	1.80	3.60	5.10	1.20	2.00	2.8
1.000	1.00	2.13	3.25	2.40	5.10	7.80	1.20	2.13	3.2
1.250	1.20	2.10	3.00	3.20	5.60	8.00	1.20	1.75	2.5
1.500	1.44	2.20	2.88	3.80	5.81	7.60	1.20	1.53	2.0
2.000	1.73	2.64	3.46	5.10	7.80	10.20	1.20	1.53	2.0
3.000	2.07	2.71	3.43	6.12	8.00	10.12	1.20	1.31	1.6
4.000	2.49	3.25	4.12	7.34	9.60	12.15	1.20	1.31	1.6
5.000	2.99	3.90	4.94	8.81	11.52	14.58	1.20	1.31	1.6

NSRP PANEL SP-4
FILE: STRCTHTS

COST ESTIMATING DATA FOR
STRUCTURAL WORK

MATERIAL: HTS

COST ESTIMATING PROCESS FACTORS

THICKNESS (INCHES)	1 FLAME CUTTING AUTO	2 FLAME CUTTING MANUAL	3 EDGE PREP GRINDING FLAT	4 EDGE PREP GRINDING VERTICAL	5 EDGE PREP GRINDING OVERHEAD	6 ASSEMBLY	7 WELDING-MACHINE FILLET	8 BUTT
0.250	0.05	0.09	0.02	0.04	0.06	0.56	0.04	na
0.375	0.05	0.09	0.03	0.05	0.07	0.56	0.05	na
0.500	0.05	0.09	0.04	0.06	0.08	0.56	0.07	0.48
0.750	0.07	0.12	0.06	0.12	0.17	0.56	0.08	0.58
1.000	0.07	0.16	0.08	0.17	0.26	0.56	0.09	0.70
1.250	0.08	0.17	0.12	0.21	0.30	0.56	0.11	0.85
1.500	0.10	0.18	0.17	0.26	0.34	0.56	0.13	1.02
2.000	0.12	0.23	0.17	0.26	0.34	0.56	0.16	1.22
3.000	0.15	0.26	0.26	0.34	0.43	0.56	0.19	1.47
4.000	0.16	0.28	0.31	0.41	0.52	0.56	0.23	1.76
5.000	0.17	0.32	0.37	0.49	0.62	0.56	0.28	2.12

THICKNESS (INCHES)	1 WELDING-MANUAL FILLET DOWN	2 FILLET VERT	3 OVHD	4 WELDING-MANUAL DOWN	5 BUTT VERT	6 OVHD	7 THICKNESS FACTOR	8 POSTION VERT	9 FACTORs OVHD
0.250	0.12	0.24	0.36	0.62	1.24	1.86	1.00	2.00	3.00
0.375	0.23	0.38	0.54	1.00	1.67	2.33	1.20	1.67	2.33
0.500	0.34	0.51	0.68	1.30	1.95	2.60	1.20	1.50	2.00
0.750	0.60	1.20	1.70	1.80	3.60	5.10	1.20	2.00	2.83
1.000	1.00	2.13	3.25	2.40	5.10	7.80	1.20	2.13	3.25
1.250	1.20	2.10	3.00	3.20	5.60	8.00	1.20	1.75	2.50
1.500	1.44	2.20	2.88	3.80	5.81	7.60	1.20	1.53	2.00
2.000	1.73	2.64	3.46	5.10	7.80	10.20	1.20	1.53	2.00
3.000	2.07	2.71	3.43	6.12	8.00	10.12	1.20	1.31	1.65
4.000	2.49	3.25	4.12	7.34	9.60	12.15	1.20	1.31	1.65
5.000	2.99	3.90	4.94	8.81	11.52	14.58	1.20	1.31	1.65

NSRP PANEL SP-4
FILE: STRTAL

COST ESTIMATING DATA FOR
STRUCTURAL WORK

MATERIAL: ALUMINUM

COST ESTIMATING PROCESS FACTORS

THICKNESS (INCHES)	1 FLAME CUTTING AUTO	2 FLAME CUTTING MANUAL	3 EDGE PREP GRINDING FLAT	4 EDGE PREP GRINDING VERTICAL	5 EDGE PREP GRINDING OVERHEAD	6 ASSEMBLY	7 WELDING-MACHINE FILLET	8 BUTT
0.250	0.05	0.09	0.02	0.04	0.06	0.56	0.04	na
0.375	0.05	0.09	0.03	0.05	0.07	0.56	0.05	na
0.500	0.05	0.09	0.04	0.06	0.08	0.56	0.07	0.48
0.750	0.07	0.12	0.06	0.12	0.17	0.56	0.08	0.58
1.000	0.07	0.16	0.08	0.17	0.26	0.56	0.09	0.70
1.250	0.08	0.17	0.12	0.21	0.30	0.56	0.11	0.85
1.500	0.10	0.18	0.17	0.26	0.34	0.56	0.13	1.02
2.000	0.12	0.23	0.17	0.26	0.34	0.56	0.16	1.22
3.000	0.15	0.26	0.26	0.34	0.43	0.56	0.19	1.47
4.000	0.16	0.28	0.31	0.41	0.52	0.56	0.23	1.76
5.000	0.17	0.32	0.37	0.49	0.62	0.56	0.28	2.12

THICKNESS (INCHES)	1 WELDING-MANUAL FILLET DOWN	2 FILLET VERT	3 OVHD	4 WELDING-MANUAL DOWN	5 BUTT VERT	6 OVHD	7 THICKNESS FACTOR	8 POSTION VERT	FACTOR OVHI
0.250	0.12	0.24	0.36	0.62	1.24	1.86	1.00	2.00	3.0
0.375	0.23	0.38	0.54	1.00	1.67	2.33	1.20	1.67	2.3
0.500	0.34	0.51	0.68	1.30	1.95	2.60	1.20	1.50	2.0
0.750	0.60	1.20	1.70	1.80	3.60	5.10	1.20	2.00	2.8
1.000	1.00	2.13	3.25	2.40	5.10	7.80	1.20	2.13	3.2
1.250	1.20	2.10	3.00	3.20	5.60	8.00	1.20	1.75	2.5
1.500	1.44	2.20	2.88	3.80	5.81	7.60	1.20	1.53	2.0
2.000	1.73	2.64	3.46	5.10	7.80	10.20	1.20	1.53	2.0
3.000	2.07	2.71	3.43	6.12	8.00	10.12	1.20	1.31	1.6
4.000	2.49	3.25	4.12	7.34	9.60	12.15	1.20	1.31	1.6
5.000	2.99	3.90	4.94	8.81	11.52	14.58	1.20	1.31	1.6

NSRP PANEL SP-4
FILE: PIP1CFE

COST ESTIMATING FORM FOR
PIPING (P1)

PROJECT: "TITLE"
FILE: XYZ123

MATERIAL: CARBON STEEL
DIA: 2 IPS
SCHEDULE 80

	WORK PROCESS	WORK UNITS	PROCESS FACTOR (MNHRS/ WORK UNIT)	UNIT AMOUNT	ACTUAL STAGE	STANDARD STAGE	ACTUAL FACTOR	STANDARD FACTOR	MNHR REQ
1	OBTAIN MATERIAL RECEIPT & PREP	PIECE	1.00	0	1	1	1.0	1.0	.0
2	CUTTING								
	MACHINE	CUT	.05	0	1	1	1.0	1.0	.0
	MANUAL	CUT	.50	0	2	2	1.5	1.5	.0
3	BENDING								
	MACHINE	BEND	.39	0	1	1	1.0	1.0	.0
	MANUAL	BEND	5.00	0	2	2	1.5	1.5	.0
4	MARKING	PIECE	.10	0	2	2	1.5	1.5	.0
5	HANDLING (KITTING)								
	STORAGE	PIECE	.10	0	2	2	1.5	1.5	.0
	TRANSPORTING	PIECE	3.00	0	2	2	1.5	1.5	.0
	LIFTING	PIECE	5.00	0	2	2	1.5	1.5	.0
6	WELDED JOINTS								
	WELDING, BUTT	JOINT	3.40	0	2	2	1.5	1.5	.0
	WELDING, SOCKET	JOINT	4.50	0	2	2	1.5	1.5	.0
7	FIT UP, ASSEMBLE & INSTALL								
	BUTT	JOINT	1.70	0	2	2	1.5	1.5	.0
	SOCKET	JOINT	1.40	0	2	2	1.5	1.5	.0
8	SURFACE PREP								
	EXTERIOR	SQ FT	.10	0	3	3	2.0	2.0	.0
	INTERIOR	SQ FT	.20	0	2	2	1.5	1.5	.0
9	COATING	SQ FT	.20	0	3	3	2.0	2.0	.0
10	INSTALLATION								
	PIPE HANGERS	HANGER	.50	0	2	2	1.5	1.5	.0
	INSULATION	LN FT	1.14	0	4	4	3.0	3.0	.0

NSRP PANEL SP-4
FILE: PIP1CFE

COST ESTIMATING FORM FOR
PIPING (P1)

PROJECT: "TITLE"
FILE: XYZ123

MATERIAL: CARBON STEEL
DIA: 2 IPS
SCHEDULE 80

WORK PROCESS	WORK UNITS	PROCESS FACTOR (MNHRS/ WORK UNIT)	UNIT AMOUNT	ACTUAL STAGE	STANDARD STAGE	ACTUAL FACTOR	STANDARD FACTOR	MNH RE
11 TESTING								
AIR	OPENINGS	.10	0	6	6	7.0	7.0	.(
HYDRO	OPENINGS	.96	0	6	6	7.0	7.0	.(
AUDIOGRAM	LIN FT	.05	0	1	1	1.0	1.0	.(
X RAYS	LIN FT	.10	0	1	1	1.0	1.0	.(

TOTAL TRADE MANHOURS		.(
TRADE SUPPORT MANHOURS (35% OF TRADE MANHOURS)		.(
TOTAL PRODUCTION MANHOURS		(
LABOR COST (MANHOURS X MNHR COST)	$20.00	$0
MATERIAL COST (FROM MATERIAL SCHEDULE)		$0
TOTAL COST		$0

NSRP PANEL SP-4
FILE: PIP1CFE

COST ESTIMATING DATA FOR PIPING (P1)

MATERIAL: CARBON STEEL
SCHEDULE 80

COST ESTIMATING PROCESS FACTORS

	1	2	3	4	5	6	7	8	9
PIPE SIZE	CUT	BEND	(FIT	UP ASSEMBLE &		AND	INSTALL)	PIPE	HYDRO
IPS	PIPE	PIPE	BUTT	SOCKET	FLANGE	THREAD	SILBRAZE	INSULATION	TEST
0.25	0.02	0.25	0.8	0.6	NA	NA	NA	0.91	0.27
0.50	0.02	0.25	1.0	0.7	NA	NA	NA	0.91	0.41
0.75	0.03	0.25	1.1	0.8	NA	NA	NA	0.91	0.55
1.00	0.03	0.25	1.2	0.9	NA	NA	NA	0.91	0.68
1.25	0.04	0.25	1.2	1.1	NA	NA	NA	1.14	0.75
1.50	0.05	0.25	1.5	1.2	NA	NA	NA	1.14	0.82
2.00	0.05	0.39	1.7	1.4	NA	NA	NA	1.14	0.96
2.50	0.06	0.39	1.9	1.6	NA	NA	NA	1.14	1.09
3.00	0.06	0.39	2.2	1.9	NA	NA	NA	1.23	1.23
3.50	0.07	0.39	2.5	2.2	NA	NA	NA	1.33	1.23
4.00	0.08	0.39	2.7	2.4	NA	NA	NA	1.41	1.36
5.00	0.08	0.39	3.1	2.7	NA	NA	NA	1.49	1.50
6.00	0.09	0.39	3.6	3.2	NA	NA	NA	1.71	1.64
8.00	0.15	0.72	4.5	4.0	NA	NA	NA	2.30	1.77
10.00	0.21	1.61	5.5	4.9	NA	NA	NA	2.58	
12.00	0.26	4.33	6.4	5.9	NA	NA	NA	2.84	
14.00	0.32	4.33	7.4	6.8	NA	NA	NA	3.13	
16.00	0.38	4.33						3.34	

WELD FACTORS

BUTT	2
SOCKET	5

SCHEDULE	40	80	160	40	80	160
PIPE SIZE	WELD	WELD	WELD	WELD	WELD	WELD
IPS	BUTT	BUTT	BUTT	SOCKET	SOCKET	SOCKET
0.25	3.0	3.0	3.1	1.9	1.7	2.2
0.50	3.0	3.0	3.1	1.9	1.7	2.2
0.75	3.0	3.0	3.1	1.9	1.7	2.2
1.00	3.0	3.0	3.1	1.9	2.2	2.8
1.25	3.0	3.0	3.3	2.2	2.5	3.4
1.50	3.0	3.2	3.3	2.4	3.0	4.6
2.00	3.0	3.4	3.8	3.5	4.5	7.2
2.50	3.5	3.5	4.5			
3.00	4.0	4.0	5.8			
3.50	4.5	4.7	6.7			
4.00	5.0	5.2	7.5			
5.00	5.2	5.9	9.9			
6.00	5.4	7.5	13.0			
8.00	6.5	10.0	17.0			
10.00	8.5	13.0	24.0			

NSRP PANEL SP-4
FILE: PIP1CRES

COST ESTIMATING DATA FOR
PIPING (P1)

MATERIAL: CRES
SCHEDULE 80

COST ESTIMATING PROCESS FACTORS

PIPE SIZE IPS	1 CUT PIPE	2 BEND PIPE	3 (FIT BUTT	4 SOCKET	5 UP ASSEMBLE & FLANGE	6 AND THREAD	7 INSTALL) SILBRAZE	8 PIPE INSULATION	9 HYDRO TEST
0.25	0.02	0.25	0.8	0.6	NA	NA	NA	0.91	0.27
0.50	0.02	0.25	1.0	0.7	NA	NA	NA	0.91	0.41
0.75	0.03	0.25	1.1	0.8	NA	NA	NA	0.91	0.55
1.00	0.03	0.25	1.2	0.9	NA	NA	NA	0.91	0.68
1.25	0.04	0.25	1.2	1.1	NA	NA	NA	1.14	0.75
1.50	0.05	0.25	1.5	1.2	NA	NA	NA	1.14	0.82
2.00	0.05	0.39	1.7	1.4	NA	NA	NA	1.14	0.96
2.50	0.06	0.39	1.9	1.6	NA	NA	NA	1.14	1.09
3.00	0.06	0.39	2.2	1.9	NA	NA	NA	1.23	1.23
3.50	0.07	0.39	2.5	2.2	NA	NA	NA	1.33	1.23
4.00	0.08	0.39	2.7	2.4	NA	NA	NA	1.41	1.36
5.00	0.08	0.39	3.1	2.7	NA	NA	NA	1.49	1.50
6.00	0.09	0.39	3.6	3.2	NA	NA	NA	1.71	1.64
8.00	0.15	0.72	4.5	4.0	NA	NA	NA	2.30	1.77
10.00	0.21	1.61	5.5	4.9	NA	NA	NA	2.58	
12.00	0.26	4.33	6.4	5.9	NA	NA	NA	2.84	
14.00	0.32	4.33	7.4	6.8	NA	NA	NA	3.13	
16.00	0.38	4.33			NA	NA	NA	3.34	

WELD FACTORS

BUTT	2
SOCKET	5

SCHEDULE	40	80	160	40	80	160
PIPE SIZE IPS	WELD BUTT	WELD BUTT	WELD BUTT	WELD SOCKET	WELD SOCKET	WELD SOCKET
0.25	4.1	4.1	7.4	0.9	1.0	1.3
0.50	4.1	4.1	7.4	0.9	1.0	1.3
0.75	4.1	4.1	7.4	0.9	1.0	1.3
1.00	4.1	4.1	7.4	0.9	1.0	1.3
1.25	4.1	7.7	7.4	1.0	1.2	1.6
1.50	4.1	7.7	7.7	1.0	1.2	1.6
2.00	6.5	9.0	9.8	1.6	1.6	2.1
2.50	9.1	9.1	11.0			
3.00	10.0	10.0	13.0			
3.50	11.0	11.0	15.0			
4.00	12.0	12.0	17.0			
5.00	12.0	14.0	22.0			
6.00	13.0	17.0	26.0			
8.00	15.0	22.0	33.0			
10.00	19.0	27.0	41.0			

NSRP PANEL SP-4
FILE: PIP1NICU

COST ESTIMATING DATA FOR
PIPING (P1)

MATERIAL: NiCu
SCHEDULE 80

COST ESTIMATING PROCESS FACTORS

PIPE SIZE IPS	1 CUT PIPE	2 BEND PIPE	3 (FIT BUTT	4 UP SOCKET	5 ASSEMBLE & FLANGE	6 AND THREAD	7 INSTALL) SILBRAZE	8 PIPE INSULATION	9 HYDRO TEST
0.25	0.02	0.25	0.8	0.6	NA	NA	NA	0.91	0.27
0.50	0.02	0.25	1.0	0.7	NA	NA	NA	0.91	0.41
0.75	0.03	0.25	1.1	0.8	NA	NA	NA	0.91	0.55
1.00	0.03	0.25	1.2	0.9	NA	NA	NA	0.91	0.68
1.25	0.04	0.25	1.2	1.1	NA	NA	NA	1.14	0.75
1.50	0.05	0.25	1.5	1.2	NA	NA	NA	1.14	0.82
2.00	0.05	0.39	1.7	1.4	NA	NA	NA	1.14	0.96
2.50	0.06	0.39	1.9	1.6	NA	NA	NA	1.14	1.09
3.00	0.06	0.39	2.2	1.9	NA	NA	NA	1.23	1.23
3.50	0.07	0.39	2.5	2.2	NA	NA	NA	1.33	1.23
4.00	0.08	0.39	2.7	2.4	NA	NA	NA	1.41	1.36
5.00	0.08	0.39	3.1	2.7	NA	NA	NA	1.49	1.50
6.00	0.09	0.39	3.6	3.2	NA	NA	NA	1.71	1.64
8.00	0.15	0.72	4.5	4.0	NA	NA	NA	2.30	1.77
10.00	0.21	1.61	5.5	4.9	NA	NA	NA	2.58	
12.00	0.26	4.33	6.4	5.9	NA	NA	NA	2.84	
14.00	0.32	4.33	7.4	6.8	NA	NA	NA	3.13	
16.00	0.38	4.33						3.34	

WELD FACTORS

BUTT	2
SOCKET	5

SCHEDULE PIPE SIZE IPS	40 WELD BUTT	80 WELD BUTT	160 WELD BUTT	40 WELD SOCKET	80 WELD SOCKET	160 WELD SOCKET
0.25	4.5	4.3	4.4	3.0	2.5	3.7
0.50	4.5	4.3	4.4	3.0	2.5	3.7
0.75	4.5	4.3	4.4	3.0	2.5	3.7
1.00	4.5	4.7	5.1	3.0	3.7	4.9
1.25	4.7	4.7	5.1	3.3	4.5	5.6
1.50	4.7	5.2	5.8	3.7	4.9	7.1
2.00	5.1	5.7	6.9	4.5	6.7	10.6
2.50	6.0	6.8	8.0			
3.00	6.6	7.6	9.6			
3.50	7.0	8.5	11.3			
4.00	7.7	10.0	13.0			
5.00	9.1	11.0	17.0			
6.00	10.0	14.0	26.0			
8.00	14.0	20.0	34.0			
10.00	17.0	24.0	51.0			

NSRP PANEL SP-4
FILE: PIP2CFE

COST ESTIMATING DATA FOR PIPING (P2)

MATERIAL: CARBON STEEL
SCHEDULE 80

COST ESTIMATING PROCESS FACTORS

PIPE SIZE IPS	1 CUT PIPE	2 BEND PIPE	3 (FIT BUTT	4 UP SOCKET	5 ASSEMBLE & FLANGE	6 AND THREAD	7 INSTALL) SILBRAZE	8 PIPE INSULATION	HYDR TES
0.250	0.020	0.250	0.8	0.6	0.5	0.3	0.22	0.91	0.2
0.500	0.020	0.250	1.0	0.7	0.6	0.3	0.23	0.91	0.4
0.750	0.030	0.250	1.1	0.8	0.6	0.4	0.24	0.91	0.5
1.000	0.030	0.250	1.2	0.9	0.6	0.4	0.27	0.91	0.6
1.250	0.040	0.250	1.2	1.1	0.7	0.4	0.28	1.14	0.7
1.500	0.050	0.250	1.5	1.2	0.7	0.4	0.30	1.14	0.8
2.000	0.050	0.390	1.7	1.4	0.8	0.5	0.32	1.14	0.9
2.500	0.060	0.390	1.9	1.6	0.8	0.5		1.14	1.0
3.000	0.060	0.390	2.2	1.9	0.9			1.23	1.2
3.500	0.070	0.390	2.5	2.2	1.0			1.33	1.2
4.000	0.080	0.390	2.7	2.4	1.0			1.41	1.3
5.000	0.080	0.390	3.1	2.7	1.0			1.49	1.5
6.000	0.090	0.390	3.6	3.2	1.1			1.71	1.6
8.000	0.150	0.720	4.5	4.0	1.1			2.30	1.7
10.000	0.210	1.610	5.5	4.9	1.2			2.58	
12.000	0.260	4.330	6.4	5.9	1.3			2.84	
14.000	0.320	4.330	7.4	6.8	1.4			3.13	
16.000	0.380	4.330						3.34	

WELD FACTORS

WELD	2
SOCKET	5

SCHEDULE PIPE SIZE IPS	40 WELD BUTT	80 WELD BUTT	160 WELD BUTT	40 WELD SOCKET	80 WELD SOCKET	160 WELD SOCKET
0.25	1.1	1.2	1.4	0.7	0.8	1.0
0.50	1.1	1.2	1.4	0.7	0.8	1.0
0.75	1.1	1.2	1.4	0.7	0.8	1.0
1.00	1.1	1.2	1.4	0.7	0.8	1.0
1.25	1.1	1.2	1.4	0.8	0.8	1.2
1.50	1.1	1.2	1.4	0.8	0.9	1.2
2.00	1.7	1.8	2.9	1.2	1.3	1.6
2.50	1.7	1.8	2.9			
3.00	1.7	1.8	2.9			
3.50	2.1	2.4	4.2			
4.00	2.1	2.4	4.2			
5.00	2.6	3.0	5.3			
6.00	3.2	3.7	6.5			
8.00	3.9	4.5	7.9			
10.00	4.7	5.4	9.5			
12.00	5.1	6.0	11.0			
14.00	5.9	6.7	12.0			
16.00	6.6	7.8	16.0			

NSRP PANEL SP-4
FILE: PIP2CRES

COST ESTIMATING DATA FOR PIPING (P2)

MATERIAL: CRES
SCHEDULE 80

COST ESTIMATING PROCESS FACTORS

	1	2	3	4	5	6	7	8	9
PIPE SIZE IPS	CUT PIPE	BEND PIPE	(FIT BUTT	UP ASSEMBLE & SOCKET	FLANGE	AND THREAD	INSTALL) SILBRAZE	PIPE INSULATION	HYDRO TEST
0.25	0.02	0.25	0.8	0.6	0.5	0.3	0.22	0.91	0.27
0.50	0.02	0.25	1.0	0.7	0.6	0.3	0.23	0.91	0.41
0.75	0.03	0.25	1.1	0.8	0.6	0.4	0.24	0.91	0.55
1.00	0.03	0.25	1.2	0.9	0.6	0.4	0.27	0.91	0.68
1.25	0.04	0.25	1.2	1.1	0.7	0.4	0.28	1.14	0.75
1.50	0.05	0.25	1.5	1.2	0.7	0.4	0.30	1.14	0.82
2.00	0.05	0.39	1.7	1.4	0.8	0.5	0.32	1.14	0.96
2.50	0.06	0.39	1.9	1.6	0.8	0.5		1.14	1.09
3.00	0.06	0.39	2.2	1.9	0.9			1.23	1.23
3.50	0.07	0.39	2.5	2.2	1.0			1.33	1.23
4.00	0.08	0.39	2.7	2.4	1.0			1.41	1.36
5.00	0.08	0.39	3.1	2.7	1.0			1.49	1.50
6.00	0.09	0.39	3.6	3.2	1.1			1.71	1.64
8.00	0.15	0.72	4.5	4.0	1.1			2.30	1.77
10.00	0.21	1.61	5.5	4.9	1.2			2.58	
12.00	0.26	4.33	6.4	5.9	1.3			2.84	
14.00	0.32	4.33	7.4	6.8	1.4			3.13	
16.00	0.38	4.33						3.34	

WELD FACTORS

BUTT	2
SOCKET	5

SCHEDULE	40	80	160	40	80	160
PIPE SIZE IPS	WELD BUTT	WELD BUTT	WELD BUTT	WELD SOCKET	WELD SOCKET	WELD SOCKET
0.25	1.4	1.6	1.8	0.9	1.0	1.3
0.50	1.4	1.6	1.8	0.9	1.0	1.3
0.75	1.4	1.6	1.8	0.9	1.0	1.3
1.00	1.4	1.6	1.8	0.9	1.0	1.3
1.25	1.4	1.6	1.8	1.0	1.2	1.6
1.50	1.4	1.6	1.8	1.0	1.2	1.6
2.00	2.2	2.3	3.8	1.6	1.6	2.1
2.50	2.2	2.3	3.8			
3.00	2.2	2.3	3.8			
3.50	2.7	3.1	5.5			
4.00	2.7	3.1	5.5			
5.00	3.4	3.9	6.9			
6.00	4.2	4.8	8.5			
8.00	5.1	5.9	10.0			
10.00	6.1	7.0	12.0			
12.00	6.6	7.8	14.0			
14.00	7.7	8.7	16.0			
16.00	8.6	10.0	19.0			

NSRP PANEL SP-4
FILE: PIP2NICU

COST ESTIMATING DATA FOR
PIPING (P2)

MATERIAL: NiCu
SCHEDULE 80

COST ESTIMATING PROCESS FACTORS

PIPE SIZE IPS	1 CUT PIPE	2 BEND PIPE	3 (FIT BUTT	4 UP SOCKET	5 ASSEMBLE & FLANGE	6 AND THREAD	7 INSTALL) SILBRAZE	8 PIPE INSULATION	9 HYDRO TEST
0.25	0.02	0.25	0.8	0.6	0.5	0.3	0.22	0.91	0.27
0.50	0.02	0.25	1.0	0.7	0.6	0.3	0.23	0.91	0.41
0.75	0.03	0.25	1.1	0.8	0.6	0.4	0.24	0.91	0.55
1.00	0.03	0.25	1.2	0.9	0.6	0.4	0.27	0.91	0.68
1.25	0.04	0.25	1.2	1.1	0.7	0.4	0.28	1.14	0.75
1.50	0.05	0.25	1.5	1.2	0.7	0.4	0.30	1.14	0.82
2.00	0.05	0.39	1.7	1.4	0.8	0.5	0.32	1.14	0.96
2.50	0.06	0.39	1.9	1.6	0.8	0.5		1.14	1.09
3.00	0.06	0.39	2.2	1.9	0.9			1.23	1.23
3.50	0.07	0.39	2.5	2.2	1.0			1.33	1.23
4.00	0.08	0.39	2.7	2.4	1.0			1.41	1.36
5.00	0.08	0.39	3.1	2.7	1.0			1.49	1.50
6.00	0.09	0.39	3.6	3.2	1.1			1.71	1.64
8.00	0.15	0.72	4.5	4.0	1.1			2.30	1.77
10.00	0.21	1.61	5.5	4.9	1.2			2.58	
12.00	0.26	4.33	6.4	5.9	1.3			2.84	
14.00	0.32	4.33	7.4	6.8	1.4			3.13	
16.00	0.38	4.33						3.34	

WELD FACTORS

BUTT	2
SOCKET	5

SCHEDULE PIPE SIZE IPS	40 WELD BUTT	80 WELD BUTT	160 WELD BUTT	40 WELD SOCKET	80 WELD SOCKET	160 WELD SOCKET
0.25	1.8	1.9	2.2	1.1	1.3	1.6
0.50	1.8	1.9	2.2	1.1	1.3	1.6
0.75	1.8	1.9	2.2	1.1	1.3	1.6
1.00	1.8	1.9	2.2	1.1	1.3	1.6
1.25	1.8	1.9	2.2	1.3	1.4	1.9
1.50	1.8	1.9	2.2	1.3	1.4	1.9
2.00	2.7	2.9	4.6	1.9	2.1	2.6
2.50	2.7	2.9	4.6			
3.00	2.7	2.9	4.6			
3.50	3.4	3.8	6.7			
4.00	3.4	3.8	6.7			
5.00	4.2	4.8	8.5			
6.00	5.1	5.9	10.0			
8.00	6.2	7.2	13.0			
10.00	7.5	8.6	15.0			
12.00	8.2	9.6	18.0			
14.00	9.4	11.0	20.0			
16.00	11.0	12.0	23.0			

NSRP PANEL SP-4
FILE:ELECT

COST ESTIMATING FORM FOR
ELECTRICAL INSTALLATIONS

PROJECT:"TITLE"
FILE:XYZ123

THRU SHIP CABLES:		A:	1	B:	1	C:	1	
LOCAL CABLES:		D:	1	E:	1	F:	1	

WORK PROCESS	WORK UNITS	PROCESS FACTOR (MNHRS/ WORK UNIT)	UNIT AMOUNT	ACTUAL STAGE	STANDARD STAGE	ACTUAL FACTOR	STANDARD FACTOR	MANHOURS REQUIRED
1 OBTAIN MATERIAL RECEIPT & PREP	PIECE	1.00	0	1	1	1.0	1.0	.0
2 HANDLING								
STORAGE	PIECE	.10	0	2	2	1.5	1.5	.0
TRANSPORTING	PIECE	1.00	0	4	4	3.0	3.0	.0
LIFTING	PIECE	1.00	0	5	5	4.5	4.5	.0
3 INSTALL THRU SHIP CABLE								
CABLE A								
NO. COLLARS	PIECE	2.70	0	2	2	1.5	1.5	.0
NO. SUPPORT TIERS	PIECE	.15	0	2	2	1.5	1.5	.0
NO. CABLE SUPPORTS	PIECE	.75	0	2	2	1.5	1.5	.0
INSTALL CABLE	LN FT	.09	0	6	6	7.0	7.0	.0
INSTALL EQUIPMT	PIECE	1.78	0	6	6	7.0	7.0	.0
CUT IN CABLE	CABLE ENDS	1.09	0	6	6	7.0	7.0	.0
CONNECT CONDUCTORS	COND END	.25	0	6	6	7.0	7.0	.0
CABLE B								
NO. COLLARS	PIECE	2.70	0	2	2	1.5	1.5	.0
NO. SUPPORT TIERS	PIECE	.15	0	2	2	1.5	1.5	.0
NO. CABLE SUPPORTS	PIECE	.75	0	2	2	1.5	1.5	.0
INSTALL CABLE	LN FT	.09	0	6	6	7.0	7.0	.0
INSTALL EQUIPMT	PIECE	1.78	0	6	6	7.0	7.0	.0
CUT IN CABLE	CABLE ENDS	1.09	0	6	6	7.0	7.0	.0
CONNECT CONDUCTORS	COND END	.25	0	6	6	7.0	7.0	.0
CABLE C								
NO. COLLARS	PIECE	2.70	0	2	2	1.5	1.5	.0
NO. SUPPORT TIERS	PIECE	.15	0	2	2	1.5	1.5	.0
NO. CABLE SUPPORTS	PIECE	.75	0	2	2	1.5	1.5	.0
INSTALL CABLE	LN FT	.09	0	6	6	7.0	7.0	.0
INSTALL EQUIPMT	PIECE	1.78	0	6	6	7.0	7.0	.0
CUT IN CABLE	CABLE ENDS	1.09	0	6	6	7.0	7.0	.0
CONNECT CONDUCTORS	COND END	.25	0	6	6	7.0	7.0	.0

NSRP PANEL SP-4
FILE:ELECT

COST ESTIMATING FORM FOR
ELECTRICAL INSTALLATIONS

PROJECT:"TITLE"
FILE:XYZ123

THRU SHIP CABLES: A: 1 B: 1 C:
LOCAL CABLES: D: 1 E: 1 F:

WORK PROCESS	WORK UNITS	PROCESS FACTOR (MNHRS/ WORK UNIT)	UNIT AMOUNT	ACTUAL STAGE	STANDARD STAGE	ACTUAL FACTOR	STANDARD FACTOR	MANHO REQUI
4 INSTALL LOCAL CABLE								
CABLE D								
INSTALL CABLE	LN FT	.02	0	4	4	3.0	3.0	
INSTALL EQUIPMT	PIECE	1.78	0	4	4	3.0	3.0	
CUT IN CABLE	CABLE ENDS	1.09	0	4	4	3.0	3.0	
CONNECT CONDUCTORS	COND END	.25	0	4	4	3.0	3.0	
CABLE E								
INSTALL CABLE	LN FT	.02	0	4	4	3.0	3.0	
INSTALL EQUIPMT	PIECE	1.78	0	4	4	3.0	3.0	
CUT IN CABLE	CABLE ENDS	1.09	0	4	4	3.0	3.0	
CONNECT CONDUCTORS	COND END	.25	0	4	4	3.0	3.0	
CABLE F								
INSTALL CABLE	LN FT	.02	0	4	4	3.0	3.0	
INSTALL EQUIPMT	PIECE	1.78	0	4	4	3.0	3.0	
CUT IN CABLE	CABLE ENDS	1.09	0	4	4	3.0	3.0	
CONNECT CONDUCTORS	COND END	.25	0	4	4	3.0	3.0	
5 GENERAL LIGHTING	LN FT	.02	0	4	4	3.0	3.0	
CONNECT CONDUCTORS	COND END	.09	0	4	4	3.0	3.0	
6 MAKE UP CONNECTORS	COND END	.20	0	4	4	3.0	3.0	
7 TESTING	CONDUCTOR	.50	0	6	6	7.0	7.0	

TOTAL TRADE MANHOURS
TRADE SUPPORT MANHOURS (35% OF TRADE MANHOURS)

TOTAL PRODUCTION MANHOURS

LABOR COST (MANHOURS X MNHR COST) $20.00 $
MATERIAL COST (FROM MATERIAL SCHEDULE) $

TOTAL COST $

COST ESTIMATING DATA FOR
ELECTRICAL INSTALLATIONS

COST ESTIMATING PROCESS FACTORS
ELECTRICAL CABLE DATA TABLE

CABLE GROUP	1 CABLE WT (UP TO LBS/FT)	2 COLLARS	3 SUPPORT TIERS	4 CABLE SUPPORTS INCL ASST	5 THRU CABLE PULL	6 LOCAL CABLE PULL	7 INSTALL EQUIPM'T	8 CUT IN CABLES	9 CONNECT CONDUCTORS
0	0	0	0	0	0	0	0	0	0
1	0.16	2.70	0.15	0.75	0.09	0.02	1.78	1.09	0.25
2	0.29	3.23	0.15	1.13	0.10	0.03	2.38	1.28	0.30
3	0.99	3.25	0.15	1.34	0.11	0.04	1.63	1.65	0.47
4	1.1	3.25	0.15	1.96	0.12	0.05	2.43	1.77	0.64
5	2	3.25	0.15	2.00	0.14	0.12	6.62	2.28	0.98
6	4	3.25	0.15	3.00	0.19	0.20	7.99	3.00	1.50
7	6	3.25	0.15	4.00	0.26	0.30	9.00	4.00	2.50
8	>6.01	3.25	0.15	5.00	0.33	0.40	10.00	5.00	4.00
9 GEN LIGHT						0.02			0.09

NSRP PANEL SP-4

FILE: HVAC

COST ESTIMATING FORM FOR
HVAC

PROJECT:"TITLE"
FILE:XYZ123

MATERIAL: SHEETMETAL PERIMETER 1 INCHES
DIAMETER 1 INCHES

WORK PROCESS	WORK UNITS	PROCESS FACTOR (MNHRS/ WORK UNIT)	UNIT AMOUNT	ACTUAL STAGE	STANDARD STAGE	ACTUAL FACTOR	STANDARD FACTOR	MNHRS REQ'D
1 OBTAIN MATERIAL RECEIPT & PREP	LN FT	.1	0	1	1	1.0	1.0	.0
2 FABRICATE DUCTS								
RECTANGULAR	LN FT	1.78	0	1	1	1.0	1.0	.0
ROUND	LN FT	.98	0	1	1	1.0	1.0	.0
3 ASSEMBLE DUCTS								
RECTANGULAR	LN FT	.21	0	1	2	1.0	1.5	.0
ROUND	LN FT	.11	0	1	2	1.0	1.5	.0
4 INSTALL DUCTS								
RECTANGULAR	LN FT	1.45	0	1	4	1.0	3.0	.0
ROUND	LN FT	1.75	0	1	4	1.0	3.0	.0
5 HANDLING (KITTING)								
STORAGE	PIECE	.1	0	1	1	1.0	1.0	.0
TRANSPORTING	PIECE	.1	0	1	3	1.0	2.0	.0
LIFTING	PIECE	.1	0	1	3	1.0	2.0	.0
6 SURFACE PREP	LN FT	.1	0	1	2	1.0	1.5	.0
7 COATING								
PAINT	LN FT	.1	0	1	3	1.0	2.0	.0
INSULATION	LN FT	.2	0	1	6	1.0	7.0	.0
8 INSTALLATION								
FOUNDATIONS	PIECE	.8	0	1	2	1.0	1.5	.0
EQUIPMENT	PIECE	16	0	1	4	1.0	3.0	.0
9 TESTING								
AIR	LN FT	.01	0	1	6	1.0	7.0	.0

TOTAL TRADE MANHOURS .0
TRADE SUPPORT MANHOURS (35% OF TRADE MANHOURS) .0

TOTAL PRODUCTION MANHOURS .0

LABOR COST (MANHOURS X MNHR COST) $20.00 $0
MATERIAL COST (FROM MATERIAL SCHEDULE) $0

TOTAL COST $0

NSRP PANEL SP-4
FILE: HVAC

COST ESTIMATING DATA FOR
HVAC WORK
MATERIAL: SHEETMETAL

COST ESTIMATING PROCESS FACTORS

DUCTWORK RECTANGULAR PERIMETER (INCHES) FROM	TO	FABRICATE	ASSEMBLE	INSTALL NWT
0	50	1.78	0.21	1.45
50	100	2.34	0.34	1.80
100	160	3.06	0.58	2.33
DUCTWORK ROUND DIAMETER (INCHES) FROM	**TO**			
0	8	0.98	0.11	1.75
8	16	1.24	0.21	2.20
16	24	1.60	0.38	2.73

Basic Language Statements for Program PRODA.BAS

```
100 'This Program, "PRODA", calculates and stores data for PRODUCIBILITY
110     Parroter Evaluation Criteria submitted by individuals.
120
130 Dim(8,8),  B(8,8),C(8),E(8),CS(8),R(8),J$(8)    'Dimensioning Work Arrays
140 COLOR 14,3
150
160
200  'MAIN PROGRAM ---------------------------- -------------
210 CLS
290 INPUT "Enter the Project or Ship Type Identifier     : ", PROJ$
299
300 ' **************  Consistency Ratio Limit Routine  ********************
305 CRLIM = .2
310 PRINT
313 COLOR 15,3:PRINT 'The data to be entered will be rejected if the data is found
to be"
315 PRINT "     excessively inconsistent.  The limit currently set for the "
320 PRINT "     consistency factor is "CRLIM".  To modify this limit, "
325  PRINT "     enter ";:COLOR 14,3:PRINT "Y";:COLOR 15,3:PRINT " now.  Any other
entry will leave the limit at "CRLIM"  :  ";: INPUT "", CRLY$
335 IF CRLY$ <> "y" AND CRLY$ <> 'Y" TEEN GOTO 360
340 PRINT: INPUT "Enter your choice for the consistency factor limit : ",cRLm
345 IF CRLIM < 1 THEN GOT0 360
350 PRINT: PRINT: PRINT "The value for consistency factor limit must be less than
1.000.  Please try again": GOTO 340
360 COLOR 14,3
370 ' l ************  End of Consistency Reading Subroutine ***************
371 '
375 PRINT: INPUT "Enter Evaluator's Name             : ", FLNAME$: PRINT
380 INPUT "Enter Evaluator's Organization       ", ORG$: PRINT
383 1F ERR = 25 THEN PRINT: INPUR "A PRINTER ERROR! IS IT ON? PRESS ENTER WHEN ON:
",ERROK$: RESUME
385 LPRINT "PRODUCIBILITY CRITERIA Weighting Evaluation for "PROJ$W Project~
386 LPRINT TAB(10) "Consistency Ratio Limit = ";: LPRINT USING "##.####"; CRLIM:
LPRINT
390 LPRINT "  Evaluation by  "FLNAME$"  of  "ORG$: LPRINT
399 '
400 '++++++++++++++++ SubRoutine "SELECTCRITERION" ++++++++++++++++++++
430 '***** Prints list of criteria from Data Section, user chooses one *******
440 CLS
450 PRINT
460 PRINT "***** Enter Criterion Code from List *****"
470 PRINT "Code","Label","                    Number of Sub-Criteria"
480 RESTORE
490 READ NUMCRIT                        ' Number of Criteria
500 FOR I = 1 TO NUMCRIT
510     READ CRITSYM$, TITLE$, NSC   'Criteria Symbols, Titles, # of SubCriteria
520      IF I>9 GOTO 550
530     PRINT TAB(2);CRITSYM$;SPC(2);TITLE$;SPC(2);NSC
540      GOTO 560
550     PRINT TAB(1);CRITSYM$;SPC(3)TITLE$;SPC(2);NSC
560 NEXT I
700 CODE$=""
```

```
770 INPUT "Enter Criterion Code to be Evaluated:  ",CODE$
780 PRINT
790 IF VAL(CODE$) >0 AND VAL(CODE$) =< NUMCRIT THEN GOTO 1000
800 '
900 ' **************  CRITERIA CODE ERROR SUBROUTINE  ********************
950 PRINT
960 INPUT "You must enter one of the Criteria Codes to Continue:  ", CODE$
9ao GOTO 790
990 ' ********* END of CODE ERROR SUBROUTINE  ***************************
999 '
1000 ' **************  CALCULATION ROUTINE  *********************************
1020 ' --------  Initializing Variables  ----------------------
1030 LM = 0
1040 CR = 0
1050 K = 1
1060 '
1200 '***************************  INPUT ROUTINE  ******************************
1201 '********************  To enter Questionnaire Data  ***********************
1230 GOTO 4000  ' To Select DAta
1240 CLS
1250 PRINT "Here are the "CLONG$" SubCriteria:"
1260 FOR I = 1 TO NC
1270    PRINT J$(I)
1280 NEXT I
1290 'PRINT
1295 'INPUT "WILL YOU USE HARD DATA FOR ANY OF THESE COMPARISONS? (Y,<N>) :",HD$
1300 LPRINT CLONG$ " Subcriteria Pairs" TAB(59) "DOMINANT ONE,  FACTOR"
1310 FOR I = 1 TO NC-1
1320    FOR J = I+1 TO NC
1325 PRINT
1330  PRINT TAB(25) "FOR COMPARISON OF "
1340 COLOR 14,1: PRINT J$(I) TAB(33)"  WITH  "J$(J);: COLOR 14,3
1342 IF HD$ = "Y" OR HD$ = "y" THEN GOTO 1345 ELSE GOTO 1350
1345 'PRINT:INPUT "WILL YOU USE HARD DATA? (Y,<N>)  : ", DTATYP$
1346 'IF DTATYP$ = "Y" OR DTATYP$ = "y" THEN GOTO 2500
1350  PRINT "WHICH HAS GREATER EFFECT ON MINIMIZING MANHOURS/COST? (";I;" OR ";J;"
    ";:INPUT "", X
1360 IF (X=I) OR (X=J) THEN GOTO 1370
1365 COLOR 14,4: PRINT "ENTRY MUST BE EITHER "I" OR "J" ! TRY AGAIN":COLOR 14,3:
PRINT : GOTO 1330
1370 INPUT "BY WHAT FACTOR?  Must Be 1 (Equal) or Greater.                    :
",Y
1375 IF Y<1 THEN GOTO 1378 ELSE GOTO 1380
1378   PRINT "DOMINANCE FACTOR MUST BE AT LEAST 1. ENTER A VALID NUMBER": GOTO 137
1380 INPUT "WANT TO CHANGE EITHER VALUE? (Y/<N>): ",X$
1390       IF (X$="Y") OR (X$="y") THEN GOTO 1325 ELSE GOTO 1400
1400            IF X = I THEN A(I,J) = Y
1410            IF X = J THEN A(I,J) = 1/Y
1420            IF X = I THEN A(J,I) = 1/Y
1430            IF X = J THEN A(J,I) = Y
1440       LPRINT J$(I)" VS "J$(J) TAB(69) X;:LPRINT USING "#####.##"; Y
1450    NEXT J
1460 NEXT I
1470 PRINT: LPRINT
1480 INPUT "ARE ALL THE ENTRIES CORRECT? (<Y>/N): ",TEST$
1490     IF (TEST$="N") OR (TEST$="n") THEN GOTO 1240
1498 '******************  END OF INPUT ROUTINE  ******************************
```

```
1499 ‘
1500 * *********  CALCULATION  ROUTINE  ************************************
1505 FOR I = 1 TO NC
1510    A(I,I) = 1
1520    E(I) = O
1530    CS(I) = O
1540    C(I) = O
1550 NEXT I
1560 FOR J = 1 TO NC
1570    FOR I = l TO NC
1580            CS(J) = CS(J)+A(I,J)
1590    NEXT I
1600 NEXT J
1610 ‘
1620 FOR I = 1 TO NC
1630    FOR J = l TO NC
1640           B(I,J) = A(I,J)/CS(J)
1650           C(I) = C(I) + B(I,J)
1660  NEXT  J
1670    C(I) = C(I)/NC
1680 NEXT I
1700 ‘
1720 ' ********  COMPUTE ROUTINE  ***********************************
1735 CR = o
1740 EF = O
1745 K = 1
1750 LA = o
1755 M = o
1760 FOR I = 1 TO NC
1770    FOR J = l TO NC
1780           E(I) = E(I) + A(I,J)*C(J)
1790  NEXT  J
1800 NEXT I
1810 FOR I = 1 TO NC
1820    LA = LA + E(I)
1830    IF K = 1 THEN LM = LM + E(I)/C(I)/NC
1840 NEXT I
1850 K = K + 1
1860 FOR I = l TO NC
1870    E(I) = E(I)/LA
1880 NEXT I
1890 FOR I = 1 TO NC
1900    IF ABS(E(I)-C(I))>.001 THEN EF = 1
1910 NEXT I
1914 FOR I = 1 TO NC
1915    C(I) = E(I)
1916 NEXT I
1920 R(l)=.01: R(2)=.01: R(3)=.58: R(4)=.9: R(5)=1.12: R(6)=1.24: R(7)=1.32
1930 R(8)=1.41
1940 RI=R(NC)
1941 IF EF = 1 THEN GOSUB 1720
1942 MU = (LM-NC)/(NC-1): CR = MU/RI
1943 PRINT: PRINT “JUDGEMEN   A R E : ”
1944 PRINT TAB(lO);"For “;CLONG$ “ Subcriteria: "
1945     FOR I = l TO NC
1946            PRINT TAB(15) J$(I);” = “;TAB(60) ;:PRINT USING “##.####”;E(I)
1947  NEXT  I
```

```
1948 'PRINT
1950 PRINT TAB(20) "Consistency Ratio = ";:PRINT USING "##.####";CR
1952 PRINT TAB(20) "Lambda Max =         ";:PRINT USING "##.####";LM
1960 '
2030 LPRINT TAB(2) "Resulting " CLONG$ " SubCriteria Weighting Factors:"
2050 FOR I= 1 TO NC
2060     LPRINT SPC(10);J$(I);" = ";TAB(65);:LPRINT USING "#.####";E(I)
2070 NEXT I
2090 LPRINT TAB(15) "Consistency Ratio =            ";:LPRINT USING "##.####";CR
2100 LPRINT TAB(15) "Lambda Max =                   ";:LPRINT USING "##.####";LM
2101 IF CR <= CRLIM THEN GOTO 2115
2102 '
2103     LPRINT "THIS CONSISTENCY RATIO IS GREATER THAN "CRLIM" AND THEREFORE THE
2104     LPRINT "DATA HAS NOT BEEN FILED":LPRINT
2105     PRINT "THESE RESULTS ARE NOT CONSISTENT ENOUGH TO BE USED.": PRINT
2106     PRINT "TO REEVALUATE, ENTER Y <Y>."
2109     PRINT "TO QUIT EVALUATING "CLONG$" SUBCRITERIA, ENTER Q"
2110     PRINT:PRINT "ENTER YOUR SELECTION (<Y> or Q) HERE  : ": I$ = INPUT$(1)
2111     IF I$ = "Q" OR I$ = "q" THEN GOTO 2280
2113     GOTO 1310
2114 '
2115 LPRINT
"*****************************************************************************":LPR
2120 '*****************  END OF COMPUTE ROUTINE **********************
2150 '
2155 '***************  ROUTINE FOR FILING DATA  ***************************
2160  PRINT: PRINT "Producing Data File"
2170 C$ = "A:\PROD\DATA\" +CODE$ + PROJ$
2180 OPEN "A",#1,C$
2190 WRITE#1,FLNAME$
2200 WRITE#1,ORG$
2210 PRINT#1,USING"##.####";LM
2220 PRINT#1,USING"##.####";CR
2230 FOR I = 1 TO NC
2240    PRINT#1,USING "##.####";E(I)
2250 NEXT I
2260 CLOSE#1
2270 '**********************  END OF FILING ROUTINE  **********************
2275 '
2280 PRINT: INPUT "Another Evaluation for the Same Person? (<Y>/N): ",P$: PRINT
2300 IF (P$="N") OR (P$="n") THEN INPUT "Start a new person? (<Y>/N): ",Q$ ELSE G
400
2310 IF (Q$="N") OR (Q$="n") THEN GOTO 2340
2320 LPRINT CHR$(12)
2325 GOTO 375
2330 '
2340 ' **********  QUITFILE SUBROUTINE  **********************************
2345 LPRINT CHR$(12)
2350 PRINT
2360 PRINT "Now exiting this program and closing the output data file."
2370 CLOSE #1
2380 END
2390 '#############################################################################
2400 '
2500 '■■■■■■■■■■■■■■■■■■■■  HARD DATA CALC ROUTINE  ■■■■■■■■■■■■■■■■■■■■■■■■■■
2502 'PRINT: PRINT " BE SURE TO USE ";:COLOR 14,5:PRINT "SMALLER";:COLOR 14,3:PRI
" VALUE FOR ";:COLOR 14,5: PRINT "SUPERIOR";: COLOR 14,3:PRINT " CHOICE"
```

```
2503 'PRINT "ZERO AND NEGATIVE VALUES ARE NOT PERMITTED"
2505 'PRINT "ENTER VALUE FOR ";:COLOR 14,2:PRINT J$(I);:COLOR 14,3: INPUT "    :
",DTAVAL(I)
2510 'PRINT: PRINT "ENTER VALUE FOR ";:COLOR 14,2:PRINT J$(J);:COLOR 14,3:INPUT "
: ",DTAVAL(J)
2512 'IF DTAVAL(I) > 0 AND DTAVAL(J) > 0 THEN GOTO 2515
2513 '   COLOR 14,5: PRINT "A ZERO OR NEGATIVE VALUE WAS ENTERED.  PLEASE TRY
AGAIN":COLOR 14,3: GOTO 2500
2515 'INPUT "WANT TO CHANGE EITHER VALUE?  (Y,<N>)    : ",YN$
2520 '  IF YN$ = "Y" OR YN$ = "y" THEN GOTO 2500
2525 'A(I,J) = DTAVAL(J)/DTAVAL(I)
2530 'A(J,I) = 1/A(I,J)
2540 'IF A(I,J) >= 1 THEN X = I ELSE X = J
2550 'IF X = I THEN Y = A(I,J) ELSE Y = A(J,I)
2560 'LPRINT J$(I)" VS "J$(J) TAB(51);:LPRINT USING
"########";DTAVAL(I);DTAVAL(J);:LPRINT "    "X;:LPRINT USING "#####.##";Y
2590 'GOTO 1450
2596 '=================== END HARD DATA CALC ROUTINE ===================
2597 '
2599 '************************* DATA SECTION ******************************
2600 DATA 21
2610 DATA "1"," PRODUCIBILITY PARAMETERS                              ",5
2620 DATA "2","   ARRANGEMENT                                         ",4
2630 DATA "3","   SIMPLICITY                                          ",3
2640 DATA "4","     Shape of Pieces                                   ",3
2650 DATA "5","   MATERIAL                                            ",2
2660 DATA "6","   STANDARDIZATION                                     ",2
2670 DATA "7","     Component Standardization                         ",3
2680 DATA "8","       Structural Components                           ",3
2690 DATA "9","   FABRICATION/ASSEMBLY                                ",6
2700 DATA "10","    Welding                                           ",2
2710 DATA "11","      Welding Process                                 ",3
2720 DATA "12","      Welding Configuration                           ",3
2721 DATA "13","        Fillet Configuration                          ",2
2722 DATA "14","    Sheetmetal                                        ",2
2723 DATA "15","    Machining                                         ",3
2724 DATA "16","    Pipefitting                                       ",5
2725 DATA "17","      Pipefitting Process                             ",2
2726 DATA "18","    Electrical/Elex                                   ",3
2727 DATA "19","      Cable Length/Size                               ",2
2728 DATA "20","    HVAC                                              ",3
2729 DATA "21","      HVAC Ducting                                    ",4
2730 '********************** END OF DATA SECTION **********************
2740 '
4000 ' *****  SELECT CRITERIA INFO SUBROUTINES  *******************************
4010 ON VAL(CODE$) GOTO
4030,4110,4210,4280,4350,4430,4510,4600,4670,4760,4840,4920,6210,6280,6350,6640,6710
,6800,6870,6960,7000
4020 '
4030 S$ = "SET 1"
4040 CLONG$ = "TOP LEVEL PRODUCIBILITY PARAMETERS"
4050 NC = 5
4060 J$(1) = "(1) ARRANGEMENT"
4070 J$(2) = "(2) SIMPLICITY"
4080 J$(3) = "(3) MATERIAL"
4082 J$(4) = "(4) STANDARDIZATION"
4085 J$(5) = "(5) FABRICATION/ASSEMBLY REQUIREMENTS"
```

```
4090 GOTO 1240
4100 ‘
4110 S$ = "SET 2“
4120 CLONG$ = "Arrangement
4130 NC=4
4140 J$(l) = "(1) ENHANCED COMPONENT PACKAGING"
4150 J$ (2) = “(2) DIRECT ROUTING OF DISTRIBUTIVE SYSTEMS”
4160 J$(3) = “(3) INTERFERENCE AVOIDANCE
4170 J$(4) = “(4) VOLUMETRIC DENSITY"
4190 GOTO 1240
4200 ‘
4210 S$ = “SET 3“
4220 CLONG$ = “SIMPLICITY”
4230 NC=3
4240 J$(l) = "(1) SHAPE OF PIECES"
4250 J$(2) = "(2) ACCESSIBILITY"
4255 J$(3) = "(3) NUMBER OF PIECES
4260 GOTO 1240
4270 ‘
4280 S$ = “SET 4“
4290 CLONG$ = "SHAPE OF PIECES"
4300 NC=3
4310 J$(l) = “(l) FLAT PLATE”
4320 J$(2) = "(2) SIMPLE CURVATURE"
4322 J$(3) = "(3) RECTANGULAR CONFIGURATIONS”
4330 GOTO 1240
4340 ‘
4350 S$ = “SET 5“
4360 CLONG$ = "MATERIAL”
4370 NC=2
4380 J$(l) = “(l) MATERIAL COSTS"
4390 J$(2) = ‘(2) WASTEAGE FACTOR"
4400 ‘ J$(3) = “(3)“
4410 GOTO 1240
4420 ‘
4430 S$ = ‘SET 6“
4440 CLONG$ = "STANDARDIZATION"
4450 NC=2
4460 J$(l) = "(1) COMPONENT STANDARDIZATION"
4470 J$(2) = "(2) PROCESS STANDARDIZATION
4490 GOTO 1240
4500 ‘
4510 S$ = "SET 7“
4520 CLONG$ = "COMPONENT STANDARDIZATION"
4530 NC=3
4540 J$(l) = "(1) StRUCTURAL"
4550 J$(2) = "(2) OUTFITTING
4560 J$(3) = “(3) EQUIPMENT"
4580 GOTO 1240
4590 ‘
4600 S$ = "SET 8“
4610 CLONG$ = "STRUCTURAL COMPONENTS”
4620 NC=3
4630 J$(l) = "(1) PLATE THICKNESS”
4640 J$(2) = "(2) SHAPES"
4642 J$(3) = "(3) SIZES"
4650 GOTO 1240
```

```
4660 ‘
4670 S$ = “SET 9“
4680 CLONG$ = "‘FABRICATION/ASSEMBLY REQUIREMENTS”
4690 NC=6
4700 J$(l) = "(1) WELDING CONSIDERATIONS"
4710 J$(2) = “(2) SHEETMETAL CONSIDERATIONS”
4720 J$(3) = "(3) MACHINING CONSIDERATIONS”
4730 J$(4) = “(4) PIPEFITTING CONSIDERATIONS"
4732 J$(5) = "(5) ELECTRICAL/ELECTRONICS”
4734 J$(6) = “(6) HVAC CONSIDERATIONS"
4740 GOTO 1240
4750 ‘
4760 S$ = "SET 10”
4765 CLONG$ = “WELDING CONSIDERATIONS”
4770 NC-2
4780 J$(l) = "(1) WELDING PROCESS”
4790 J$(2) = "(2) WELDING CONFIGURATION”
4820 GOTO 1240
4830 ‘
4840 S$ = "SET 11”
4850 CLONG$ = "WELDING PROCESS”
4860 NC=3
4870 J$(l) = “(1) AUTOMATION ACHIEVED"
4880 J$(2) = “(2) POSITION OPTIMIZATION"
4890 J$(3) = "(3) HEAT TREATMENT”
4900 GOTO 1240
4910 ‘
4920 S$ = “SET 12”
4930 CLONG$ = WELDING CONFIGURATION"
4940 NC=3
4950 J$(l) = "(1) FILLET CONFIG’N"
4960 J$(2) = “(2) WELD LENGTH"
4970 J$(3) = “(3) WELD TYPE”
4990 GOTO 1240
5000 ‘
6210 S$ = “SET 13"
6220 CLONG$ = “FILLET CONFIGURATION”
6230 NC=2
6235 J$(l) = “(1) PLATE BEVEL ANGLES”
6255 J$(2) = "(2) NUMBER OF PASSES"
6260 GOTO 1240
6270 ‘
6280 S$ = "SET 14”
6290 CLONG$ = “SHEETMETAL”
6300 NC-2
6310 J$(l) = "(l) CONFIGURATION”
6320 J$(2) = “(2) PROCESS REQUIRED”
6330 GOTO 1240
6340 ‘
6350 S$ = "SET 15”
6360 CLONG$ = "MACHZNING"
6370 NC=3
6380 J$(l) = "(1) USE OF COMMON FOUNDATIONS"
6390 J$(2) = “(2) MOUNTING DETAILS”
6600 J$(3) = “(3) INSTALLATION”
6610 GOTO 1240
6620 ‘
```

```
6630 S$ = "SET 16”
6640 CLONG$ = "PIPEFITTING CONSIDERATIONS"
6650 NC=5
6660 J$(l) = “(l) PIPEFITTING PROCESS”
6670 J$ (2) = “(2) PIPE SIZE”
6680 J$ (3) = “(3) PIPE LENGTH”
6682 J$(4) = “(4) PIPE MATERIAL”
6684 J$ (5) = “(5) PIPING SUPPORT NEEDS”
6690 GOTO 1240
6700 ‘
673.0 S$ = “SET 17”
6720 CLONG$ = “PIPEFITTING PROCESS”
6730 NC-2
6740 J$(l) = “(1) USE OF BENDS VICE FITTINGS”
6770 J$(2) = “(2) CONNECTION TYPE"
6780 GOTO 1240
6790 ‘
6800 S$ = “SET 18”
6810 CLONG$ = "ELECTRICAL/ELECTRONICS CONSIDERATIONS”
6820 NC-3
6830 J$(l) = "(1) CABLE LENGTH/SIZE”
6840 J$(2) = “(2) CONNECTIONS/HOORUPS”
6842 J$(3) = “(3) WIREWAYS”
6850 GOTO 1240
6860 ‘
6870 S$ = “SET 19"
6880 CLONG$ = “ELECT/ELEX CABLES”
6890 NC=2
6900 J$(l) = “(1) LENGTH”
6910 J$(2) = “(2) SIZE"
6940 GOTO 1240
6950 ‘
6960 S$ = "SET 20”
6967 CLONG$ = "HVAC CONSIDERATIONS"
6970 NC-3
6980 J$(l) = “(1) HVAC DUCTING”
6990 J$(2) = “(2) HVAC EQUIPMENT INSTALLATION”
6995 J$(3) = “(3) EVAC INSULATION"
6997 GOTO 1240
6999 ‘
7000 S$ = “ SET 21”
7010 CLONG$ = “HVAC DUCTING”
7020 NC=4
7030 J$(l) = “(1) DUCT SIZE”
7040 J$(2) = "(2) DUCT LENGTH"
7050 J$(3) = “(3) DUCT MATERIAL TYPE"
7060 J$(4) = "(4) DUCT CONFIGURATION CHANGES”
7070 GOTO 1240
8000 END
```

Basic Language Statements for Program PRODB.BAS

```
100 'THIS IS PROGRAM PRODB. BAS, WHICH DEVELOPS THE COMBINED WEIGHTING VALUES
101 `   FOR THE PRODUCIBILITY CRITERIA WHICH INDIVIDUALLY DETERMINED WITH
102 '   PROGRAM PRODA.BAS.
103 '
105 COLOR 14,3
195 '
200  DIM  A$(8),T(8),GT(8),J$  (8)  ,u$(50),V$(50),SUMED(8),AVGED(8),NGM(8)
205 CLOSE
300 CLS
301 INPUT "ENTER PROJECT OR SHIP TYPE IDENTIFIER     : ", PROJ$
302 IF ERR-25 GOTO 304
303 GOTO 306
304 PRINT: INPUT "PRINTER ERROR. IS IT TURNED ON? PRESS ENTER WHEN IT IS.
";ERRORS: RESUME
306 LPRINT: LPRINT "PRODUCIBILITY CRITERIA Weighting Factors for the "PROJ$"
Project": LPRINT
310 CLS
320 '  **********  CRITERIA SELECTION ROUTINE  ******************************
330 PRINT ***************** CRITERIA CODE LISTING  ************************
340 PRINT TAB(8) "Code" TAB(18)  "Title" TAB(50) "Number of Sub-Criteria"
350 RESTORE
360 READ NUMCRIT                          ` Number of Criteria
370 FOR I = l To NUMCRIT
380    READ CRITSYM$, TITLE$, NSC    0'Criteria Symbols, Titles, # of
SubCriteria
390    PRINT TAB(l0); CRITSYM$;SPC(2) TITLE$;SPC(2);NSC
400 NEXT I
402 NUMCR$ = STR$(NUMCRIT)
404 IF NUMCRIT <10 THEN NUMCR$ = RIGHT$(NUMCR$,l) ELSE NUMCR$ =
RIGHT$ (NUMCR$,2)
410 '          Criteria Code Selection Process Begins
420 CODE$=""
430 PRINT "Enter 99 to Generate Mean Values for All Criteria, or"
440 INPUT "Enter Code Number of Criterion to be Evaluated          :  ",CODE$
445 CODE = VAL(CODE$)
450 IF CODE <= NUMCRIT THEN FLAG = 1: GOTO 1050
460 IF CODE$ = "99" THEN 1010
470 INPUT "THAT IS AN INVALID ENTRY.  TRY AGAIN OR QUIT? (<T>/Q): ",Q$
480 IF ((Q$="Q") OR (Q$="q")) = GOTO 1710 ELSE GOTO 310
490 '
500 '
1000   ****************************************************************
1010 FLAG = O
1020 FOR CRIT = 1 TO NUMCRIT
1030     s$ = STR$(CRIT)
1040     IF CRYT < 10 THEN CODE$ = RIGHT$(s$,l) ELSE CODE$ = RIGHT$(S$,2)
1050 C$ = "A:\PROD\DATA\" + CODE$ + PROJ$
1055 GOSUB 4000
1058 LPRINT
1059 ON ERROR GOTO 1063
1060 OPEN"I",#l,C$
1062 GOTO 1070
```

```
1063 PRINT “THERE ARE NO ENTRIES FOR CRITERION “CLONG$” ON THE “PROJ$"
PROGRAM”
1064 CLOSE #1
1065 IF FLAG = O THEN RESUME 1067
1066 RESUME 1670
1067 NEXT CRIT
1070 TCR=O
1080 LMT=1
1090 CRT=l
1096 SUMGTI = O
1100 RCOUNT-O
1105 LPRINT “Individuals’ Weights for:  "CLONG$"  SubCriteria are: ": LPRINT
1110 FOR I = 1 TO NC
1120     T(I) = 1
11256    SUMED (I) = O
1130 NEXT I
1140 IF EOF (l) THEN GOTO 1310
1150 RCOUNT = RCOUNT + 1
1160  INPUT#l,U$(RCOUNT)
1170  INPUT#l,V$(RCOUNT)
1180 INPUT#l,LM
1190 INPUT#l,CR
1195 LPRINT U$(RCOUNT) “ of “ V$(RCOUNT) TAB(61) “WEIGHT”
1200 LMT = LMT*LM
1210 ‘CRT = CRT*CR
1220 FOR I = 1 TO NC
1230     INPUT#l,ED
1250  T(I)-T(I)*ED
1260     SUMED(I) = SUMED(I) + ED
1265   LPRINT J$(I) TAB(60); : LPRINT USING “##.####”; ED
1270 NEXT I
1275 LPRINT TAB(10) "Consistency Ratio = ";:LPRINT USING “##.####";CR
1276 LPRINT TAB(10) "Lambda Max =        ";:LPRINT USING "##.####";LM
1277  LPRINT
1280 GOTO 1140
1290 ‘
1310  CLOSE#l
1320 CLS
1330 1 ******** CALCULATE PROGRAM **********
1350 GLMT=O    "INITIALISE TOTAL COUNTERS
1360 GCRT=O
1370 GOSUB 4000
1380 FOR I = 1 TO NC
1390    GT(I) = O
1400 NEXT I
1410 ‘FOR I = 1 TO RCOUNT
1420 ‘  LPRINT U$(I) TAB(30) V$(I)
1430 ‘NEXT I
1439 PRINT “For "CLONG$" SubCriteria Weights,”
1440 PRINT: PRINT “ There were “RCOUNT” Evaluators. The Geometric Means of
their responses are:”
1450 LPRINT "The total number of respondents = “;RCOUNT
1460 PRINT : LPRINT
```

```
1480 LPRINT “The Normalized Geometric Mean of the above individual evaluations
of”
1485 LPRINT CLONG$ “ SubCriteria Weights for the * “PROJ$” * project are :“
1495 LPRINT “
NGM"
1500 FOR I = 1 TO NC
1510     GT(I) = T(I)^(l/RCOUNT)
1512     SUMGTI = SUMGTI + GT(I)
1515 NEXT I
1516 FOR I = 1 TO NC
1517    NGH(I) = GT(I)/SUMGTI
1518    AVGED(I) = SUMED(I)/RCOUNT
1520    PRINT J$(I) TM3(25) “value = "TAB(58);:PRINT USING "###.####”;NGM(I)
1530   LPRINT J$(I) TAB(58);:LPRINT USING “####.####”;NGM(I)
1540 NEXT I
1550 PRINT : LPRINT
1560 GLMT = LMT”(l/RCOUNT)
1570 'GCRT = CRT^(l/RCOUNT)
1580 PRINT “The Geometric Mean of Lambda Max Total = “;:PRINT USING “##.####”;
GLMT: PRINT
1590 LPRINT "The Geometric Mean Of Lambda Max Total = “;:LPRINT USING
“##.####”;G-
1591 LPRINT
n**************************************************************************w
1595 ‘LPRINT CHR$(12)
1600 PRINT : LPRINT
1650 IF FLAG = 1 THEN GOTO 1670
1660 NEXT CRIT
1665 IF FLAG = O THEN GOTO 1690
1670 INPUT “Evaluate more Criteria for the same Project? (<Y>/N): “,Q2$
1680 IF Q2$ = "N” OR Q2$ = “n” THEN GOTO 1690 ELSE GOTO 306
1690 INPUT "Want To Evaluate Criteria for another Project? (Y/<N>):   “,Q3$
1700 IF Q3$ = "y” OR Q3$ = “Y” THEN LPRINT CHR$(12) : GOTO 300
1710 CLOSE#1
1720 LPRINT CHR$(12)
1730 END
1740 '
2590 '************************* DATA SECTION  l  **************************
2600 DATA 21
2610 DATA "1"," PRODUCIBILITY PARAMETERS                                ",5
2620 DATA "2",”   Arrangement                                          ",4
2630 DATA "3","   SIMPLICITY                                           ",3
2640 DATA "4”,"     Shape of Pieces                                    ",3
2650 DATA "5", MATERIAL                                                ",2
2660 DATA "6”,"   STANDARDIZATION                                      ",2
2670 DATA "7","     Component  Standardization                         ",3
2680 DATA "8","       structural Components                            ",3
2690 DATA "9","   FABRICATION/ASSEMBLY                                 ",6
2700 DATA "10","    Welding                                            ",2
2710 DATA "1l","      Welding Process                                  ",3
2720 DATA "12”,”      Welding  Configuration                           ",3
2721 DATA “13”,”        Fillet  Configuration                          ",2
2722 DATA "14”,”    Sheetmetal                                         ",2
2723 DATA “15”,”    Machining                                          ",3
```

```
2724 DATA “16”, ”    Pipefitting                                          “,5
2725 DATA ‘17”, ”      Pipefitting  Process                               11,2
2726 DATA “18”, ”    Electrical/Elex                                      “,3
2727 DATA "19",’      Cable  Length/Size                                   ",2
2728 DATA “20",”     HVAC                                                 ",3
2729 DATA “21”,"       HVAC Ducting                                       ",4
2730  '********************  END OF DATA SECTION  ************************
2740 ‘
4000 ' *****  SELECT CRITERIA INFO SUBROUTINES  ******************************
4010 ON VAL(CODE$) GOTO
4030,4110,4210,4280,4350,4430,4510,4600,4670,4760,4840,4920,6210,6280,6350,664
0,6710,6800,6870,6960,7000
4020 ‘
4030 S$ = "SET 1“
4040 CLONG$ = “Top LEVEL PRODUCIBILITY PARAMETERS"
4050 NC = 5
4060 J$(I) = "(1) ARRRANGEMENT"
4070 J$(2) = "(2) SIMPLICITY”
4080 J$(3) = “(3) MATERIAL”
4082 J$(4) = “(4) STANDARDIZATION”
4085 J$(5) = “(5) FABRICATION/ASSEMBLY REQUIREMENTS"
4090 RETURN
4100 ‘
4110 S$ = “SET 2“
4120 CLONG$ = “ARRANGEMENT"
4130 NC=4
4140 J$(l) = “(l) ENHANCED COMPONENT PACKAGING"
4150 J$(2) = “(2) DIRECT ROUTING OF DISTRIBUTIVE SYSTEMS"
4160 J$(3) = “(3)  INTERFERENCE  AVOIDANCE”
4170 J$(4) = “(4) VOLUMETRIC DENSITY"
4190 RETURN
4200 ‘
4210 S$ = “SET 3"
4220 CLONG$ = “SIMPLICITY"
4230 NC=3
4240 J$(l) = “(1) SHAPE OF PIECES"
4250 J$(2) = “(2) ACCESSIBILITY"
4255 J$(3) = “(3)  NUMBER OF PIECES
4260  RETURN
4270 ‘
4280 S$ = “SET 4“
4290 CLONG$ = “SHAPE OF PIECES"
4300 NC=3
4310 J$(l) = "(l) FLAT PLATE"
4320 J$(2) = “(2) SIMPLE CURVATURE
4322 J$(3) = “(3) RECTANGULAR CONFIGURATIONS”
4330 RETURN
4340 ‘
4350 S$ = “SET 5“
4360 CLONG$ = “MATERIAL"
4370 NC=2
4380 J$(l) = "(1) MATERIAL COSTS”
4390 J$(2) = "(2) WASTEAGE FACTOR"
4400 ‘ J$(3) = “(3) "
```

```
4410 RETURN
4420 '
4430 s$ = "SET 6"
4440 CLONG$ = "STANDARDIZATION”
4450 NC=2
4460 J$(l) = “(1) COMPONENT STANDARDIZATION”
4470 J$(2) = “(2) PROCESS STANDARDIZATION”
4490 RETURN
4500
4510 S$ = “SET 7“
4520 CLONG$ = "COMPONENT STANDARDIZATION"
4530 NC=3
4540 J$(l) = “(1) STRUCTURAL”
4550 J$ (2) = "(2) OUTFITTING”
4560 J$ (3) = "(3) EQUIPMENT”
4580 RETURN
4590
4600 S$ = "SET 8“
4610 CLONG$ = “STRUCTURAL COMPONENTS”
4620 NC=3
4630 J$ (1) = “(1) PLATE THICKNESS”
4640 J$ (2) = “(2) SHAPES”
4642 J$ (3) = “(3) SIZES"
4650 RETURN
4660
4670 s$ = “SET 9“
4680 CLONG$ = “FABRICATION/ASSEMBLY REQUIREMENTS”
4690 NC=6
4700 J$ (1) = "(1) WELDING CONSIDERATIONS"
4710 J$ (2) = " (2) SHEETMETAL CONSIDERATIONS"
4720 J$ (3) = “ (3) MACHINING CONSIDERATIONS”
4730 J$(4) = “ (4) PIPEFITTING CONSIDERATIONS”
4732 J$ (5) = “ (5) ELECTRICAL/ELECTRONICS”
4734 J$(6) = “(6) HVAC CONSIDERATIONS"
4740 RETURN
4750
4760 S$ = "SET 10"
4765 CLONG$ = “WELDING CONSIDERATIONS"
4770 NC=2
4780 J$ (1) = " (1) WELDING PROCESS”
4790 J$ (2) = “ (2) WELDING CONFIGURATION”
4820 RETURN
4830
4840 S$ = " SET 11”
4850 CLONG$ = “WELDING PROCESS"
4860 NC=3
4870 J$ (1) = “ (1) AUTOMATION ACHIEVED"
4880 J$ (2) = " (2) POSITION OPTIMIZATION"
4890 J$ (3) = " (3) HEAT TREATMENT"
4900 RETURN
4910
4920 S$ = "SET 12”
4930 CLONG$ = "WELDING CONFIGURATION"
4940 NC=3
```

```
4950 J$(l) = “ (1)  FILLET  CONFIG‘N“
4960 J$ (2) = " (2)  WELD  LENGTH”
4970 J$ (3) = “ (3)  WELD  TYPE"
4990 RETURN
5000
6210 S$ = "SET 13"
6220 CLONG$ = “FILLET  CONFIGURATION"
6230 NC=2
6235 J$(l) = “ (1) PLATE BEVEL ANGLES”
6255 J$ (2) = “ (2)  NUMBER  OF  PASSES"
6260 RETURN
6270
6280 S$ = “SET 14"
6290 CLONG$ = “SHEETMETAL"
6300 NC=2
6310 J$ (1) = " (1) CONFIGURATION"
6320 J$ (2) = “ (2) PROCESS REQUIRED"
6330 RETURN
6340
6350 S$ = "SET 15"
6360 CLONG$ = "Machining"
6370 NC=3
6380 J$ (1) = “ (1) USE OF COMMON FOUNDATIONS"
6390 J$ (2) = " (2) MOUNTING DETAILS"
6600 J$ (3) = “ (3) INSTALLATION"
6610 RETURN
6620
6630 S$ = “SET 16”
6640 CLONG$ = “PIPEFITTING  CONSIDERATIONS"
6650 NC=5
6660 J$(l) = " (1)  PIPEFITTING  PROCESS”
6670 J$ (2) = " (2)  PIPE SIZE"
6680 J$(3) = " (3)  PIPE LENGTH"
6682 J$(4) = " (4)  PIPE MATERIAL"
6684 J$ (5) = " (5)  PIPING  SUPPORT NEEDS"
6690 RETURN
6700
6710 S$ = "SET 17”
6720 CLONG$ = “PIPEFITTING  PROCESS"
6730 NC=2
6740 J$(l) = " (1) USE OF BENDS VICE FITTINGS"
6770 J$ (2) = “ (2) CONNECTION TYPE"
6780 RETURN
6790
6800 S$ = "SET 18"
6810 CLONG$ = "ELECTRICAL/ELECTRONICS CONSIDERATIONS“
6820 NC=3
6830 J$ (1) = " (1) CABLE LENGTH/SIZE"
6840 J$ (2) = “ (2) CONNECTIONS/HOOKUPS"
6850 J$ (3) = " (3) HIREWAYS”
6860 RETURN
6865
6870 S$ = "SET 19"
6880 CLONG$ = "ELECT/ELEX CABLES"
```

```
6890 NC=2
6900 J$ (l) = "(l) LENGTH”
6910 J$ (2) = “(2) SIZE”
6940 RETURN
6950 '
6960 S$ = “SET 20”
6967 CLONG$ = "HVAC CONSIDERATIONS”
6970 NC=3
6980 J$(l) = "(1) HVAC DUCTING"
6990 J$(2) = “(2) HVAC EQUIPMENT INSTALLATION"
6995 J$(3) = “(3) HVAC INSULATION”
6997 RETURN
6999 ‘
7000 S$ = “ SET 21”
7010 CLONG$ = "HVAC DUCTING”
7020 NC=4
7030 J$(l) = “(1) DUCT SIZE”
7040 J$(2) = “(2) DUCT LENGTH”
7050 J$(3) = “(3) DUCT MATERIAL TYPE”
7060 J$(4) = “(4) DUCT CONFIGURATION CRANGES”
7070 RETURN
7080 ‘
8000 END
```

```
100 'This Program, "PRODC", calculates and stores an individual's choice
110  of weighting factors for each design variant for each criteria evaluated,
111 ' and then prints out the data so it can be used in a spreadsheet  program.
120
130 DIM  A(3,3),  B(3,3),C(3),E(3),CS(3),R(9),J$(9),ALT$(3)  'Dimensioning Work Arrays
140 COLOR 14,3
150 CRLIM =  .2   set default consistency ratio limit
160
170 'MAIN PROGRAM ------------------------  ----------------
180 CLS
200 INPUT "Enter the Project or Ship Type Identifier                    : ", PI
210 PRINT : INPUT "Enter the design change being evaluated
", CHANGE$
300 '
310 '++++++++++++++   Naming Design Alternatives   ++++++++++++++++++++++++
315 FLAG = 3
316 PRINT
320 INPUT "Enter a TITLE for Alternative 1 (8 letters or less)          : ",
ALT$ (1)
340 PRINT: INPUT "Enter a TITLE for Alternative 2 (8 letters or less)
",ALT$(2)
350 PRINT: INPUT "Now name Alternative 3 (8 letters) or press ENTER to bypass
",ALT$(3)
370 IF ALT$(3) = "" THEN FLAG = 2: DTAVAL(3) = 0
375 PRINT: PRINT "The Alternatives you have chosen are listed below:":PRINT
380 PRINT "        Alternative 1 is     " ALT$(l)
382 PRINT "        Alternative 2 is     "ALT$ (2)
384 IF FLAG = 3 THEN PRINT "        Alternative 3 is     "ALT$(3) ELSE PRINT "No
Alternative 3"
385 PRINT: PRINT "Are these Alternatives Correct? (<Y>/N) :   ": Q1$ = INPUT$(l)
386 IF Q1$ = "N" OR Ql$ = "n" THEN GOTO 310
387 IF FLAG = 2 THEN NALT = 2 ELSE NALT = 3
388 IF FLAG = 2 TEEN GOTO 393
389 '
390 GOSUB 2400 '   validate or reset consistency factor limit
391 IF ERR=25 THEN PRINT: INPUT "PRINTER ERROR. IS IT ON? PRESS ENTER WHEN IT IS.
", ERROR$: RESUME
393 CLS: PRINT :INPUT "Enter Name of Evaluator : ", FLNAME$
394 PRINT: INPUT "Enter Evaluator's Organization: ", ORG$: PRINT
395 LPRINT TAB(2) " PRODUCIBILITY CRITERIA EVALUATION of Design Alternatives for
"PROJ$" Program"
396 LPRINT TAB(8) "Design Variant:   "CHANGE$ TAB(40)"       Consistency Ratio Limit
= ";:LPRINT USING "#.####";CRLIM
397
399
400 '+++++++++++++++++ SubRoutine "SELECTCRITERION" ++++++++++++++++++++
430 '***** Prints list of criteria from Data Section, user chooses one *******
440 'CLS
450 PRINT
460 PRINT "************************ Criterion Code List ************************
470 PRINT "Code","Label","                    Number of Sub-Criteria"
480 RESTORE
490 READ NUMCRITE                       ' Number of Criteria
500 FOR I = 1 TO NUMCRITE
510     READ CRITSYM$, TITLE$, NSC   'Criteria Symbols, Titles, # of SubCriteria
520   IF VAL(CRITSYM$) > 9 THEN GOTO 550
```

```
530     PRINT TAB(2); CRITSYM$; SPC(2); TITLE$; SPC(2);NSC
540      GOTO 560
550     PRINT TAB(l);CRITSYM$; SPC(3)TITLE$;SPC(2);NSC
560 NEXT I
580 PRINT
700 CODE$=""
770 INPT "Enter Criterion Code to be Evaluated:  ",CODE$
780 PRINT
790 IF VAL(CODE$) >0 AND VAL(CODE$) <= NUMCRITE TEEN GOTO 4000
799 '
940 ' **************  CRITERIA CODE ERROR SUBROUTINE l ********************
950 PRINT
960 INPT "You must enter one of the Criteria Codes to Continue (or Q to Quit) : ",
CODE$
980 IF CODE$= 'q" OR CODE$ ="Q" THEN GOTO 2340 ELSE 790 : PRINT "Thank you"
990 ' ********* END Of CODE ERROR SUBROUTINE  ***************************
999 '
1000 '  ==========  DATA ENTRY AND EVALUATION  ==========================
1002 CLS
1003 PRINT "Here are the "CLONG$" SUBCRITERIA:"
1004 FOR N = 1 TO NC
1005    PRINT J$(N)
1006 NEXT N
1007 PRINT
1008 '         --- print headings ---
1010 LPRINT: LPRINT "   "CLONG$" Subcriteria Weighting Evaluation"
1011 LPRINT "--------------------------  -------------------------------------  ---
1013 LPRINT "SUBCRITERIA";TAB(50);"DESIGN ALTERNATIVES
1015 IF FLAG = 2 THEN GOTO 1018
1016  LPRINT  TAB(44);ALT$(l);TAB(54);ALT$(2);TAB(64);ALT$(3);TAB(74);"CRATIO":  LPRINT
1017 GOTO 1100
1018 LPRINT TAB(44);ALT$ (l);TAB(54);ALT$(2);TAB(74);"CRATIO" : LPRINT
1020 '
1099 '         --- select from list of subcriteria ---
1100 INPT "WILL YOU EVALUATE EACH (E), SOME (<S>) OR ONE (1) OF THESE? : ", SBCH$
1102 IF SBCH$ = "E" OR SBCH$ = "e" THEN SBCHFLAG = 0: GOTO 1315
1105 IF SBCE$ = "1" THEN SBCHFLAG = 1 ELSE SBCHFLAG =2
1110       INPT "Which CRITERION will you  evaluate? Enter its number:  ", N
1115       PRINT:IF N > NC THEN PRINT "THE NUMBER MUST BE LESS THAN "NC". TRY
AGAIN":PRINT:GOTO  1110
1117      HD$ = "T"
1120 GOTO 1325
1200 '
1300 ' ******** EVALUATIoN ROUTINE ************************************
1305 '
1315 INPT "WILL YOU USE HARD DATA FOR ANY OF THESE COMPARISONS? (Y,<N>) : ",HD$
1320 FOR N = 1 TO NC
1322    GOTO 1325
1322 NEXT N
1323 GOTO 2300
1324 '
1325 PRINT
1330 PRINT "FOR CRITERION ";: COLOR 14,1: PRINT J$(N);: COLOR 14,3
1332 IF HD$ = "Y" OR HD$ = "Y" THEN GOTO 1335 ELSE GOTO 1344
1335 PRINT:INPT "WILL YOU USE HARD DATA? (Y,<N>) : ", DTATYP$
1336 IF DTATYP$ = "Y" OR DTATYP$ = "y" TEEN GOTO 2500
```

```
1340 ‘
1343  LPRINT
1344 LPRINT J$(N) “ Data “:LPRINT TAB(8) “ ALTS” TAB(44) “DOMINANT ALT SUP
FACTOR”
1345 FOR I = 1 TO NALT-1
1346    FOR J = I+1 TO NALT
1349  PRINT
1350 PRINT “IS “;:COLOR 14,5:PRINT "(”I")";:COLOR 14,1:PRINT “ “ALT$(I);:COLOR
14,3:PRINT “ OR “;:COLOR 14,5:PRINT "(”J")";:COLOR 14,1:PRINT “ “ALT$(J);:COLOR
14,3:PRINT "SUPERIOR? "TAB(70):INPUT ": ",X
1360 IF X=1 OR X=J THEN GOTO 1370
1364     PRINT: COLOR 14,4
1365     PRINT “ENTRY MUST BE EITEER “I” OR “J" ! TRY AGAIN";: COLOR 14,3:
PRINT:GOTO 1349
1369 ‘
1370 INPUT “FACTOR OF SUPERIORITY   MUST BE 1 (EQUAL) OR GREATER
",Y
1375 IF Y < 1 TEEN PRINT: GOTO 1370
1380 INPUT “WANT TO CHANGE EITEER VALUE? (Y/<N>): “,X$
1390       IF (X$="Y") OR (X$=”Y”) THEN GOTO 1349 ELSE GOTO 1400
1400            IF X= I THEN A(I,J)= Y
1410            IE X = J THEN A(I,J) = l/Y
1420            IF X = I THEN A(J,I) = l/Y
1430            IF X = J THEN A(J,I)= Y
1440 LPRINT TAB(2) "("I”) “ AT$(I) TAB(18) “VS  (“J”) “ ALT$(J) TAB(50) X TAB(55);
LPRINT USING "######.##”; Y
1450  NEXT  J
1460 NEXT I
1470 PRINT
1480 INPUT “ARE ALL TEE ENTRIES CORRECT? (<Y>/N): “,TEST$
1485 PRINT
1490     IF (TEST$="N") OR (TEST$=”n”) THEN GOTO 1325
1500 FOR I = 1 TO NALT
1510    A(I,I) = 1      ‘Initializing array values
1520    E(I) = O
1530    CS(I) = O
1540    C(I) = O
1550 NEXT I
1560  FOR J = 1 TO NALT                  ‘Calculating Columu Sums
1570    FOR I = l TO NALT
1580            CS(J) = CS(J)+A(I,J)
1590  NEXT  I
1600  NEXT J
1610 ‘
1620 FOR I = 1 TO NALT
1630    FOR J = l TO NALT
1640            B(I,J) = A(I,J)/CS(J)
1650            C(I) = C(I) + B(I,J)
1660  NEXT  J
1670    C(I) = C(I)/NALT
1600 NEXT I
1690 '************ End of INPUT Routine  **********************
1700 ‘
1701  '********  Calculate values for CR and LM **********************
1702 LM = O       ‘ Initializing Lambda Max
1703 CR = o       ' Initializing Consistency Ratio
1704 R-l
```

```
1710 '
1720 ' ********  COMPUTE ROUTINE  ************************************
1730 ' ********  Fill the Arrays - Do the Math ************************
1740 EF = 0
1750 LA = 0
1760 FOR I = 1 TO NALT
1770    FOR J = 1 TO NALT
1780            E(I) = E(I) + A(I,J)*C(J)
1790    NEXT J
1800 NEXT I
1810 FOR I = 1 TO NALT
1820    LA = LA + E(I)
1830    IF K = 1 THEN LM = LM + E(I)/C(I)/NALT
1840 NEXT I
1850 K = K + 1
1860 FOR I = 1 TO NALT
1870    E(I) = E(I)/LA
1880 NEXT I
1890 FOR I = 1 TO NALT
1900    IF ABS(E(I)-C(I))>.001 THEN EF = 1
1910 NEXT I
1914 FOR I = 1 TO NALT
1915    C(I) = E(I)
1916 NEXT I
1920 R(1)=.01: R(2)=.01: R(3)=.58: R(4)=.9: R(5)=1.12: R(6)=1.24: R(7)=1.32
1930 R(8)=1.41
1940 RI=R(NALT)
1941 IF EF = 1 THEN GOTO 1740
1942 MU = (LM-NALT)/(NALT-1): CR = MU/RI
1943 PRINT "JUDGEMENTS ARE:"
1944 PRINT TAB(10);"FOR: ";J$(N)
1945     FOR I = 1 TO NALT
1946             PRINT TAB(15) ALT$(I);" = ";TAB(60);:PRINT USING "##.####";E(I)
1948    NEXT I
1949 IF FLAG = 2 THEN GOTO 2000
1950 PRINT TAB(20) "Consistency Ratio = ";:PRINT USING "##.####";CR
1951 PRINT TAB(20) "Lambda Max =        ";:PRINT USING "##.####";LM
1952 'PRINT
1953 IF CR <= CRLIM THEN GOTO 2000
1954  LPRINT "THESE DATA ARE NOT CONSISTENT ENOUGH TO BE USED.": LPRINT
1955  PRINT "THESE DATA ARE NOT CONSISTENT ENOUGH TO BE USED.": PRINT
1956  PRINT "TO REEVALUATE,                          ENTER Y <Y>."
1957  PRINT "TO EVALUATE ANOTHER CRITERION,          ENTER A "
1959  PRINT "TO QUIT EVALUATING "CLONG$" SUBCRITERIA, ENTER Q"
1960  PRINT:PRINT "ENTER YOUR SELECTION (<Y>, A or Q) HERE  : ": I$ = INPUT$(1)
1962  IF I$ = "Q" OR I$ = "q" THEN GOTO 2300
1965  IF I$ = "A" OR I$ = "a" THEN GOTO 1980
1968    INPUT "Press Enter to Continue"; MORE$
1970  GOTO 1325
1980  IF FLAG = 2 THEN E(1) = .5: E(2) = .5: CR = 0: GOTO 2000
1990  E(1) = .33333: E(2) = .33333: E(3) = .33333: CR = 0
1998 '*****************  END OF COMPUTE ROUTINE **********************
1999 '
2000 '**********************  PRINT ROUTINE  ***************************
2050 INPUT "TO CONTINUE, Press <Y>   ", ERROK$
2055   IF FLAG = 2 THEN GOTO 2070
```

```
2060     LPRINT CLONG$ " " J$(N) " Weights" ;TAB(40);:LPRINT USING
"######.####";E(1);E(2);E(3);CR
2065     GOTO 2075
2070   LPRINT CLONG$ " " J$(N) " Weights" ;TAB(40);:LPRINT USING
"######.####";E(1);E(2);:LPRINT SPC(10);:LPRINT USING "####.####";CR
2075 LPRINT TAB(43) "****************************"
2078 '*********************  END OF PRINT ROUTINE ****************************
2079 '
2080 IF SBCHFLAG = 0 THEN GOTO 1322
2081 IF SBCHFLAG = 1 THEN GOTO 2300
2082 '     ---  for SBCHFLAG = 2  ----
2085 PRINT: PRINT "Here are the "CLONG$" SUBCRITERIA:"
2086 FOR N = 1 TO NC
2087    PRINT J$(N)
2088 NEXT N
2089 PRINT: PRINT "WANT TO EVALUATE ANOTHER SUBCRITERION OF "CLONG$ ;: INPUT "?
(<Y>,N)  :", YN$
2090     IF YN$ = "N" OR YN$ = "n" THEN GOTO 2300
2095 GOTO 1110
2100 '
2150 '
2300 LPRINT "-------------------------------------------------------------------
--------"
2301 INPUT "Another Evaluation for the Same Person? (<Y>/N): ",P$
2305 IF (P$="N") OR (P$="n") THEN INPUT "Start a new person? (<Y>/N): ",Q$ ELSE G
400
2310 IF (Q$="N") OR (Q$="n") THEN GOTO 2340
2320 LPRINT CHR$(12)
2325 GOTO 393
2330 '
2340 ' **********  QUITFILE SUBROUTINE  **********************************
2350 PRINT
2360 PRINT "Exiting this program."
2365 LPRINT CHR$(12)
2380 END
2390 '#############################################################################
2400 '
2402 ' **************  Consistency Reading Subroutine  *********************
2405 PRINT
2410 COLOR 15,3:PRINT "The data to be entered will be rejected if the data is fou
to be"
2415 PRINT "    excessively inconsistent.  The limit currently set for the "
2420 PRINT "    consistency ratio is "CRLIM".  To modify this limit, enter ";:COL(
14,3:PRINT "Y";:COLOR 15,3:PRINT " now."
2425 PRINT "    Any other entry will leave the value at "CRLIM"          :  ";:
INPUT "", CRLY$
2435 IF CRLY$ <> "y" AND CRLY$ <> "Y" THEN GOTO 2460
2440 PRINT: INPUT "Enter your choice for the consistency factor limit          :
",CRLIM
2445 IF CRLIM < 1 THEN GOTO 2460
2450 PRINT: PRINT: PRINT "The value for consistency ratio limit must be less than
1.000.  Please try again": GOTO 2405
2460 COLOR 14,3: RETURN
2470 ' *************  End of Consistency Reading Subroutine  ***************
```

```
2499 ‘
2500 ' *************  HARD DATA SUBROUTINE  *********************************
2501 IF VAL(CODE$) = 1 AND N = 4 THEN GOTO 2600
2502 IF VAL(CODE$) = 2 AND N = 5 THEN GOTO 2600
2503 IF VAL(CODE$) = 3 THEN GOTO 2600
2504 IF VAL(CODE$) = 4 THEN GOTO 2600
2505 IF VAL(CODE$) = 5 AND N > 2 THEN GOTO 2600
2506 IF VAL(CODE$) = 6 THEN GOTO 2600
2507 IF VAL(CODE$) = 7 AND N = 3 THEN GOTO 2600
2508 IF VAL(CODE$) > 7 THEN GOTO 2600
2510 ‘
2520 PRINT: PRINT “ BE SURE TO USE “;:COLOR 14,5:PRINT “LARGER”;:COLOR 14,3:PRINT II
VALUE FOR ";:COLOR 14,5: PRINT "SUPERIOR”;: COLOR 14,3:PRINT “ CHOICE”
2521 PRINT “ZERO AND NEGATIVE VALUES ARE NOT PEBMITTED”
2522 PRINT "ENTER VALUE FOR ";: COLOR 14,9:PRINT ALT$(l);:COLOR 14,3: PRINT
TAB(50);:INPUT “    : ",DTAVAL(l)
2523 PRINT: PRINT “ENTER VALUE FOR ";: COLOR 14,9:PRINT ALT$(2);:COLOR 14,3:PRINT
TAB(50);:INPUT ": ",DTAVAL(2)
2524 IF FLAG = 2 AND DTAVAL(l) >0 AND DTAVAL(2) >0 THEN GOTO 2528
2525 PRINT: PRINT “ENTER VALUE FOR “;:COLOR 14,9:PRINT ALT$(3);:COLOR 14,3:PRINT
TAB(50): INPUT “    : ",DTAVAL(3)
2526 IF DTAVAL(l) > 0 AND DTAVAL(2) > 0 AND DTAVAL(3) >0 THEN GOTO 2528
2527    COLOR 14,5: PRYNT “A ZERO OR NEGATIVE VALUE HAS ENTERED.  PLEASE TRY
AGAIN”:COLOR 14,3: GOTO 2520
2528 INPUT "WANT TO CHANGE ANY OF THE VALUES? (Y,<N>) :  ",X$
2529    IF X$ = “Y" OR X$ = “y” THEN GOTO 2520
2530 LPRINT: LPRINT J$(N) "Data” TAB(38);:LPRINT USING
"#######.##";DTA-(l);DTAVAL(2);DTAVAL(3)
2531 A(1,2) = DTAVAL(l)/DTAVAL(2)
2532 A(2,1) = l/A(l,2)
2535 IF FLAG = 2 THEN GOTO 2560
2540 A(1,3) = DTAVAL(l)/DTAVAL(3)
2545 A(3,1) = l/A(l,3)
2550 A(2,3) = DTAVAL(2)/DTAVM(3)
2555 A(3,2) = l/A(2,3)
2560 GOTO 1500
2575
2600 PRINT: PRINT "BE SURE TO USE “;:COLOR 14,5:PRINT "SMALLER:;:COLO         14,3:PRINT "
VALUE FOR ";:COLOR 14,5: PRINT "SUPERIOR";: COLOR 14,3:PRINT " CHOICE"
2605 PRINT “ZERO AND NEGATIVE VALUES ARE NOT PERMITTED”
2609 PRINT ‘ENTER VALUE FOR ";:COLOR 14,9:PRINT ALT$(l);:COLOR 14,3:PRINT
TAB(50);:INPUT ": “,DTA.(1) .
2610 PRINT: PRINT “ENTER VALUE FOR “;:COLOR 14,9:PRINT ALT$(2);:COLOR 14,3:PRINT
TAB(50);:INPUT "    : ",DTAVAL(2)
2615 IF FLAG = 2 AND DTAVAL(l) >0 AND DTAVAL(2) >0 THEN GOTO 2625
2620 PRINT: PRINT ‘ENTER VALUE FOR “;:COLOR 14,9:PRINT ALT$(3);:COLOR 14,3:PRINT
TAB(50);:INPUT "    : ",DTAVAL(3)
2622 IF DTAVAL(l) > 0 AND DTAVAL(2) > 0 AND DTAVAL(3) >0 THEN GOTO 2625
2623    COLOR 14,5: PRINT “A ZERO OR NEGATIVE VALUE HAS ENTERED.  PLEASE TRY
AGAIN":COLOR 14,3: GOTO 2600
2625 INPUT “WANT TO CHANGE ANY OF THE VALUES? (Y,<Y>) :  “,x$
2626    IF X$ = "Y” OR X$ = "y" THEN GOTO 2600
2630 LPRINT: LPRINT J$(N) " Data" TAB(38);:LPRINT USING
“#######.##";DTAVAL(l);DTAVAL(2);DTAVAL(3)
2635 A(1,2) = DTAVAL(2)/DTAVAL(l)
2640 A(2,1) = l/A(l,2)
2645 IF FLAG = 2 THEN GOTO 2670
```

```
2650 A(1,3) = DTAVAL(3) /DTAVAL(l)
2655 A(3,1) = l/A(l,3)
2660 A(2,3) = DTAVAL(3)/DTAVAL(2)
2665 A(3,2) = l/A(2,3)
2670 GOTO 1500
2690 ' *****************  END of HARD DATA Subroutine  *******************
2699
3000 '************************  DATA SECTION  ●**************************
3005 DATA 10
3010 DATA "l"," ARRANGEMENT                                              ",4
3020 DATA "2","   SIMPLICITY                                             "t5
3050 DATA "3"," MATERIAL                                                 ",2
3060 DATA "4","   STANDARDIZATION                                        ",6
3080 DATA "5","   Welding                                                ",6
3090 DATA "6","   Sheetmetal                                             ",2
3100 DATA "7","   Machining                                              ",3
3110 DATA "8","   Pipefitting                                            ",6
3120 DATA "9","   Electrical/Elex                                        ",4
3130 DATA "10","  HVAC                                                   ",6
3135 '*********************  END OF DATA SECTION  *************************
3500
4000 ' *****  SELECT CRITERIA INFO SUBROUTINES  ●***************************
4010 ON VAL(CODE$) GOTO 4030,4110,4210,4280,4360,4430,4510,4600,4760,4840
4020
4030 S$ = "SET in
4040 CLONG$ = "ARRANGEMENT"
4050 N C = 4
4060 J$(l) = "(l) ENHANCED COMPONENT PACKAGING
4070 J$(2) = "(2) DIRECT ROUTING OF DISTRIBUTIVE SYSTEMS"
4080 J$(3) = "(3) INTERFERENCE AVOIDANCE"
4082 J$(4) = "(4) VOLUMETRIC DENSITY"
4090 GOTO 1000
4100
4110 S$ = "SET 2"
4120 CLONG$ = "SIMPLICITY"
4130 NC-5
4140 J$(1) = "(1) FLAT PLATE"
4150 J$(2) = "(2) SIMPLE PLATE CURVATURE"
4160 J$(3) = "(3) RECTANGULAR CONFIGURATIONS"
4170 J$(4) = "(4) ACCESSIBILITY"
4180 J$(5) = "(5) NUMBER OF PIECES"
4190 GOTO 1000
4200 '
4210 S$ = "SET 3"
4220 CLONG$ = "MATERIAL"
4230 NC=2
4240 J$(1) = "(1) MATERIAL COSTS"
4250 J$(2) = "(2) WASTEAGE FACTOR"
4260 GOTO 1000
4270 '
4280 S$ = "SET 4"
4290 CLONG$ = "STANDARDIZATION"
4300 NC=6
4310 J$(1) = "(1) PLATE THICKNESS"
4320 J$(2) = "(2) SHAPES"
4322 J$(3) = "(3) PLATE AND SHAPE SIZES"
4324 J$(4) = "(4) OUTFITTING ITEMS"
```

```
4326 J$ (5) = "(5) EQUIPMENT”
4328 J$(6) = “(6) PROCESS STANDARDIZATION”
4330 GOTO 1000
4340
4360 s$ = “SET 5“
4365 CLONG$ = “WELDING CONSIDERATIONS"
4370 NC=7
4300 J$ (l) = “(1) AUTOMATION POTENTIAL”
4390 J$ (2) = “(2) OPTIMUM POSITION POTENTIAL”
4400 J$ (3) = "(3) HEAT TREATMENT REQMTS."
4402 J$ (4) = “(4) FILLET BEVEL ANGLES”
4404 J$ (5) = "(5) NUMBER OF PASSES”
4406 J$(6) = “(6) WELD LENGTH”
4408 J$(7) = "(7) WELD TYPE”
4410 GOTO 1000
4420
4430 S$ = "SET 6“
4440 CLONG$ = “SHEETMETAL"
4450 NC-2
4460 J$(l) = “(1) CONFIGURATION"
4470 J$(2) = “(2) PROCESS STANDARDIZATION”
4490 GOTO 1000
4500
4510 S$ = “SET 7"
4520 CLONG$ = WACHINING"
4530 NC=3
4540 J$ (1) = “(1) COMMONALITY OF FOUNDATIONS”
4550 J$ (2) = "(2) SIMPLICITY OF MOUNTING"
4560 J$ (3) = “ (3) EASE OF INSTALLATION/HOOKUP/TEST”
4580 GOTO 1000
4590
4600 S$ = "SET 8“
4610 CLONG$ = "PIPEFITTING”
4620 NC=6
4630 J$ (1) = “ (1) BENDING TECHNIQUE USED”
4640 J$ (2) = “ (2) CONNECTION TYPE USED”
4642 J$ (3) = “ (3) PIPE SIZE”
4644 J$(4) = “(4) PIPE LENGTH"
4646 J$ (5) = " (5) PIPE MATERIAL TYPE”
4648 J$(6) = “(6) PIPE SUPPORT NEEDS”
4650 GOTO 1000
4750
4760 S$ = "SET 9"
4780 CLONG$ = “ELECTRICAL/ELECTRONIC"
4790 NC=4
4800 J$(l) = “ (1) CABLE LENGTH”
4810 J$ (2) = “ (2) CABLE TYPE”
4812 J$ (3) = " (3) CONNECTION/HOOKUPS”
4814 J$(4) = “(4) WIREWAY”
4820 GOTO 1000
4830
4840 s$ = " SET 10”
4850 CLONG$ = "HVAC"
4860 NC=6
4870 J$(l) = “ (1) DUCTING SIZE”
4880 J$ (2) = “ (2) DUCTING LENGTH”
4890 J$ (3) = " (3) DUCTING MATERIAL"
```

```
4892 J$ (4) = "(4) DUCT Configuration CHANGES”
4894 J$ (5) = "(5) HVAC EQUIPMENT INSTALLATION"
4896 J$(6) = :"(6) HVAC INSULATION"
4900 GOTO 1000
5000 END
```

GW-BASIC Statements for Program DECA. BAS

```
100 'This Program, "DECA. BAS", calculates and stores data for DECISION
110 '   MAKING Parameter Evaluation Criteria submitted by individuals.
120 '
130 DIM A(8,8), B(8,8),C(8),E(8),CS(8),R(8) ,J$(8) 'Dimensioning Work Arrays
140 COLOR 14,3
150 CRLIM = .2
160 '
200 'MAIN PROGRAM ---------- ----------
210 CLS
290 INPUT "Enter the Project or Ship Type Identifier:  ", PROJ$
310 ' **************  Consistency Ratio Limit Routine  ********************
312 PRINT
313 COLOR 15,3:PRINT 'The data tO be entered will be rejected if the data is found
to be"
315 PRINT "    excessively inconsistent.  The limit currently set for the "
320 PRINT "    consistency factor is "CRLIW.  To modify thiS limit, "
325 PRINT "     enter ";:COLOR 14,3:PRINT "Y" ;:COLOR 15,3:PRINT " now.  Any other
 entry will leave the limit at "CRLIM" :  ";: INPUT "", CRLY$
335 IF CRLY$ <> "y" AND CRLY$ <> "Y" THEN GOTO 360
340 PRINT: INPUT "Enter your choice for the consistency factor limit : ",CRLIM
345 IF CRLIM < 1 THEN GOTO 360
350 PRINT: PRINT: PRINT "The value for consistency factor limit must be less than
1.000.  Please try again": GOTO 340
360 COLOR 14,3
370 ' **************  End of Consistency Reading Subroutine ***************
371 FLNAMES$ = ""
372 ORG$=""
375 PRINT: INPUT "Enter Evaluator's Name          : ", FLNAME$
380 PRINT: INPUT "Enter Evaluator's Organization : ", ORG$: PRINT
381 IF ERR=25 THEN PRINT: INPUT "PRINTER ERROR.  IS IT ON? PRESS ANY KEY WHEN IT IS
ON. ", ERROR$: RESUME
385 LPRINT "DECISION MAKING Criteria weighting Evaluation for the "PROJ$" project
386 LPRINT TAB(10) 'Consistency Ratio Limit = ";: LPRINT USING "##.####"; CRLIM:
390 LPRINT: LPRINT " Evaluated by  "FLNAME$" of "ORG$"  ++++++++++++++++++++++":
LPRINT
399 '
400 '+++++++++++++++++ SubRoutine "SELECTCRITERION" ++++++++++++++++++++
430 '***** Prints list Of criteria from Data Section, user chooses one *******
440 CLS
450 PRINT
460 PRINT "******************* Criterion Code List l *****************W
470  PRINT  "  code","Label","                    Number of Sub-Criteria"
480 RESTORE
490 READ NUMCRIT                      ' Number of Criteria
500 FOR I = 1 TO NUMCRIT
510     READ CRITSYM$, TITLE$, NSC   'Criteria Symbols, Titles, # of SubCriteria
520      IF 1>9 GOTO 550
530     PRINT TAB(2) ;CRITSYM$;SPC(2) ;TITLE$;SPC(2) ;NSC
540      GOTO 560
550     PRINT TAB(1) ;CRITSYM$;SPC(3)TITLE$;SPC(2) ;NSC
560 NEXT I
700 CODE$=""
770 INPUT "Enter Criterion Code to be Evaluated:  ",CODE$
780 PRINT
790 IF VAL(CODE$) >0 AND VAL(CODE$) =< NUMCRIT THEN GOTO 1000
910 '
```

```
940 ' ***************  CRITERIA CODE ERROR SUBROUTINE    ********************
950 PRINT
960 INPUT "You must enter one of the Criteria Codes to Continue: ", CODE$
980 GOTO 790
990 ' ***************  END of CODE ERROR SUBROUTINE  **********************
1000 '
1010 ' *********  CALCULATION ROUTINE ************************************
1020 ' *****  Calculate values for CR and LM  ****************************
1030 LM = o       ' Initializing Lambda Max
1040 CR = o       ' Initializing Consistency Ratio
1050 K=1
1060 '
1220 '*************************  INPUT ROUTINE  *************************
1221 '*******************  To enter Evaluator's Data  ********************
1230 GOTO 4000   ' To Select DAta
1240 CLS
1250 PRINT: PRINT "Here are the "S$" "CLONG$" SUBCRITERIA:"
1260 FOR I = 1 TO NC
1270    PRINT TAB(10) J$(I)
1280 NEXT I
1295 'INPUT "WILL YOU USE HARD DATA FOR ANY OF THESE COMPARISONS? (Y,<N>) :",H
1300 LPRINT CLONG$" SubCriteria Pairs" TAB(58) " DOMINANT ONE,  FACTOR"
1310 FOR I = 1 TO NC-1
1320    FOR J = I+l TO Nc
1325 PRINT
1330 PRINT TAB(5) "FOR COMPARISON OF "
1340 COLOR 14,1: PRINT J$(I) TAB(33)" WITH "J$(J);: COLOR 14,3
1342 'IF HD$ = "Y" OR HD$ = "y" THEN GOTO 1345 ELSE GOTO 1350
1345 'PRINT:INPUT "WILL YOU USE HARD DATA? (Y,<N>) : ", DTATYP$
1346 'IF DTATYP$ = "Y" OR DTATYP$ = "y" THEN GOTO 2500
1349 PRINT
1350 PRINT "IS ";:COLOR 14,1:PRINT I;:COLOR 14,3:PRINT " OR ";:COLOR 14,1:PRIN
J;:COLOR 14,3:PRIYNT " MORE IMPORTANT to the "PROJ$" Program?          :    ";:IN
"",X
1360 IF (X=I) OR (X-J) THEN GOTO 1370
1361 '
1365 COLOR 14,4: PRINT "ENTRY MUST BE EITHER "I" OR "J" ! TRY AGAIN":COLOR 14,
PRINT : GOTO 1330
1369 '
1370 PRINT TAB(10):INPUT "BY WHAT FACTOR? Must be 1 (EQUAL) or Greater :
1372 IF Y < 1 THEN GOTO 1374 ELSE GOTO 1380
1374   INPUT "FACTOR MUST BE GREATER THAN 1.  PLEASE REENTER FACTOR : ", Y
1380 INPUT "WANT TO CHANGE EITHER VALUE? (Y/<N>): ",X$
1390       IF (X$="X") OR (X$="Y") THEN GOTO 1325 ELSE GOTO 1400
1400            IF X = I THEN A (I,J)= Y
1410            IF x = J THEN A(I,J) = I/Y
1420            IF X = I THEN A(J,I) = l/Y
1430            IF X = J THEN A(J,I)= Y
1440       LPRINT J$(I)" VS "J$(J) TAB(69) X;:LPRINT USING "#####.##"; Y
1450  NEXT  J
1460 NEXT I
1470 PRINT: LPRINT
1480 INPUT "ARE ALL THE ENTRIES CORRECT? (<Y>/N): ",TEST$
1485 PRINT
1490     IF (TEST$="N") OR (TEST$="n") THEN GOTO 1240
1500 FOR I = 1 TO NC
1510    A(I,I) = 1
1520    E(I) = O
```

```
1530    CS(I) = O
1540    C(I) = O
1550 NEXT I
1560 FOR J = 1 TO NC
1570    FOR I=1 TO NC
1580            CS(J) = CS(J)+A(I,J)
1590    NEXT I
1600 NEXT J
1610 '
1620 FOR I = 1 TO NC
1630    FOR J = l TO NC
1640            B(I,J) = A(I,J)/CS(J)
1650            C(I) = C(I) + B(I,J)
1660  NEXT  J
1670    C(I) = C(I)/NC
1680 NExt I
1690 ‘************ End of INPuT Routine l *********************
1700 ‘
1710 ‘
1720 ' ********  COMPUTE ROUTINE    **********************************
1730  ' *******  Fill the Arrays - Do the Math  **********************
1740 EF = 0
1750 LA = 0
1760 FOR I = 1 TO NC
1770    FOR J = l TO NC
1780           E(I) = E(I) + A(I,J)*C(J)
1790  NEXT  J
1800 NEXT I
1810 FOR I = 1 TO NC
1820    LA = LA + E(I)
1830    IF K = 1 THEN LM = LM + E(I)/c(I)/Nc
1840 NEXT I
1850 K = K + 1
1860 FOR I = 1 TO NC
1870    E(I) = E(I)/LA
1880 NEXT I
1890 FOR I = l TO NC
1900    IF ABS(E(I)-C(I))>.001 THEN EF - 1
1910 NEXT I
1914 FOR I = 1 TO NC
1915    C(I) = E(I)
1916 NEXT I
1920 R(l)=.01: R(2)=.01: R(3)=.58: R(4)=.9: R(5)=1.12: R(6)=1.24: R(7)=1.32
1930 R(8)=1.41
1940 RI-R(NC)
1941 IF EF = 1 THEN GOSUB 1720
1942 MU = (LM-NC)/(NC-1): CR = MU/RI
1943 PRINT “JUDGEMENTS  ARE:”
1944 PRINT TAB(10) “FOR “ CLONG$ "  Subcriteria"
1945     FOR I = l TO NC
1946             PRINT TAB(15) J$(I);” = ";TAB(60) ;:PRINT  USING  "##.####”;E(I)
1947  NEXT  I
1950 PRINT TAB(20) "Consistency Ratio = ";:PRINT USING "##.####w;cR
1952 PRINT TAB(20) “Lambda Max =        ";:PRINT USING ‘##.####";124
1955 '*****************  END OF COMPUTE ROUTINE  **********************
1960 ‘
1969 '**********************  PRINT ROUTINE  l ************************
```

```
1970 'PRINT
2000 'PRINT "in PRINT ROUTINE"
2030 LPRINT TAB(3) "Resulting "CLONG$" SubCriteria Weighting Factors"
2050 FOR I= 1 TO NC
2060     LPRINT SPC(5);J$(I);" = ";TAB(65);:LPRINT USING "#.####";E(I)
2070 NEXT I
2090 LPRINT TAB(15);"CONSISTENCY RATIO =            ";:LPRINT USING "##.####";Cl?
2100 LPRINT TAB(15);"LAM8DA MAX =                   ";:LPRINT USING "##O####tI;~
2102 IF CR <= CRLIM TEEN GOTO 2110
2103     PRINT "THESE RESULTS ARE NOT CONSISTENT ENOUGH TO BE USED.": PRINT
2105     LPRINT "THIS CONSISTENCE RATIO IS GREATER THAN "CRLIM" AND THEREFORE THE
2106     LPRINT "DATA HAS NOT BEEN FILED":LPRINT
2108     GOTO 2280
2110 LPRINT
"*************************************************************************
LPRINT
2130 'PRINT 'Leaving PRINT ROUTINE": PRINT
2140 '******************* END OF PRINT ROUTINE  ***********************
2150 '
2155 '************** ROUTINE FOR FILING DATA  ●************************
2160 PRINT "Producing Data File"
2170 C$ = "A:\DEC\DATA\" +CODE$ + PROJ$
2180 OPEN "A",#l,C$
2190 WRITE#l, FLNAME$
200 WRITE#l,ORG$
2210 PRINT#l,USING"##.####" ;LM
2220 PRINT#l,USING"##.####" ;CR
2230 FOR I = 1 TO NC
2240    PRINT#l,USING  "##.####";E(I)
2250 NEXT I
2260 CL0SE#l
2270 '*********************  END OF FILING ROUTINE  ***********************
2275 '
2280 INPUT "Another Evaluation for the Same Person? (<Y>/N): ",P$
2300 IF (P$="N") OR (P$="n") TEEN INPUT "Start a new person? (<Y>/N): ",Q$ ELSE
400
2310 IF (Q$="N")  OR (Q$="n") THEN GOTO 2340
2320 LPRINT CER$(12)
2322 CLS
2325 GOTO 370
2330 '
2340 ' ********** QUITFILE ROUTINE  *********************************
2350 PRINT
2360 PRINT "Now exiting this program and closing the output data file."
2370 CLOSE #1
2375 LPRINT CER$(12)
2380 END
2390    '#########################################################################
2400 '
2500 '==================  HARD DATA CALC ROUTINE  ============================
2502 'PRINT: PRINT "A LARGER VALUE WILL BE CONSIDERED TEE SUPERIOR CHOICE"
2503 'PRINT "ZERO AND NEGATIVE VALUES ARE NOT PERMITTED"
2505 'PRINT "ENTER VALUE FOR ";:COLOR 14,2:PRINT J$(I);:COLOR 14,3: INPUT " :
",DTAVAL(I)
2510 'PRINT: PRINT "ENTER VALUE FOR ";:COLOR 14,2:PRINT J$(J);:COLOR 14,3:INPUT "
: ",DTAVAL(J)
2512 'IF DTAVAL(I) > 0 AND DTAVAL(J) > 0 THEN GOTO 2515
```

```
2513 '   COLOR 14,5: PRINT "A ZERO OR NEGATIVE VALUE WAS ENTERED.  PLEASE TRY
AGAIN":COLOR 14,3: GOTO 2500
2515 'INPUT "WANT TO CHANGE EITHER VALUE?  (Y,<N>)    : ",YN$
2520 '  IF YN$ = "Y" OR YN$ = "y" THEN GOTO 2502
2525 'A(I,J) = DTAVAL(I)/DTAVAL(J)
2530 'A(J,I) = 1/A(I,J)
2540 'IF A(I,J) >= 1 THEN X = I ELSE X = J
2550 'IF X = I THEN Y = A(I,J) ELSE Y = A(J,I)
2560 'LPRINT J$(I)" VS "J$(J) TAB(51);:LPRINT USING
"########";DTAVAL(I);DTAVAL(J);:LPRINT "    "X;:LPRINT USING "#####.##";Y
2590 'GOTO 1450
2595 END
2596 ==================  END HARD DATA CALC ROUTINE  ==================
2597 '
2599 '************************  DATA SECTION  ****************************
2600 DATA 18
2610 DATA "  1"," TOP LEVEL CRITERIA                                    ",4
2615 DATA "  2","   COST RELATED CRITERIA                               ",3
2617 DATA "  3","     Non-Recurring Costs                                ",5
2619 DATA "  4","     Service Life Costs                                 ",3
2620 DATA "  5","   SCHEDULE RELATED CRITERIA                           ",4
2622 DATA "  6","   RISK RELATED CRITERIA                               ",4
2625 DATA "  7","   SHIP PERFORMANCE                                    ",3
2628 DATA "  8","     OPERATIONAL CAPABILITY                             ",5
2630 DATA "  9","       Payload Carrying Capacity                        ",2
2640 DATA "  10","      Payload Effectiveness                            ",2
2650 DATA "  11","      Mobility                                         ",3
2660 DATA "  12","      Availability                                     ",3
2670 DATA "  13","        Operability in Extreme Conditions              ",4
2680 DATA "  14","      Survivability                                    ",2
2690 DATA "  15","        Detection Avoidance                            ",4
2700 DATA "  16","        Damaged Operability                            ",4
2710 DATA "  17","    EFFICIENCY OF OPERATION                            ",3
2720 DATA "  18","    FUTURE GROWTH CAPABILITY                           ",4
2730 '*********************  END OF DATA SECTION  **************************
2740 '
4000 ' *****  SELECT CRITERIA INFO SUBROUTINES  *******************************
4010 ON VAL(CODE$) GOTO
4030,4110,4210,4280,4350,4360,5030,5110,5210,5280,5350,5430,5510,5600,5670,5760,5840
,5920
4020 '
4030 S$ = "SET 1"
4040 CLONG$ = "TOP LEVEL CRITERIA
4050 NC = 4
4060 J$(1) = "(1) COST"
4070 J$(2) = "(2) SCHEDULE"
4080 J$(3) = "(3) RISK"
4082 J$(4) = "(4) PERFORMANCE"
4090 GOTO 1240
4100 '
4110 S$ = "SET 2"
4120 CLONG$ = "COST RELATED CRITERIA
4130 NC=3
4140 J$(1) = "(1) RECURRING SHIPBLDG COSTS
4150 J$(2) = "(2) NON-RECURRING SHIPBLDG COSTS
4160 J$(3) = "(3) SERVICE LIFE COSTS"
4190 GOTO 1240
```

```
4200 '
4210 S$ = "SET 3"
4220 CLONG$ = "NON-RECURRING COSTS"
4230 NC=5
4240 J$(1) = "(1) DESIGN AND ENGINEERING"
4250 J$(2) = "(2) PRODUCTION PLANNING"
4255 J$(3) = "(3) PRODUCTION AIDS / TOOLING
4256 J$(4) = "(4) DISRUPTION"
4257 J$(5) = "(5) DELAY"
4260 GOTO 1240
4270 '
4280 S$ = "SET 4"
4290 CLONG$ = "SERVICE LIFE COSTS"
4300 NC=3
4310 J$(1) = "(1) PERSONNEL"
4320 J$(2) = "(2) CONSUMABLES"
4322 J$(3) = "(3) MAINTENANCE"
4330 GOTO 1240
4340 '
4350 S$ = "SET 5"
4351 CLONG$ = "SCHEDULE RELATED CRITERIA"
4352 NC=4
4354 J$(1) = "(1) DESIGN/ENGINEERING SCHEDULE"
4355 J$(2) = "(2) EQPMNT/MAT'L PURCHASE SKED"
4356 J$(3) = "(3) CONSTRUCTION SCHEDULE"
4357 J$(4) = "(4) TEST AND TRIALS SCHEDULE"
4358 GOTO 1240
4359 '
4360 S$ = "SET 6"
4365 CLONG$ = "RISK RELATED CRITERIA"
4370 NC=4
4380 J$(1) = "(1) MATURITY OF TECHNOLOGY"
4390 J$(2) = "(2) YARD EXPERIENCE"
4400 J$(3) = "(3) COST ESTIMATE CONFIDENCE"
4402 J$(4) = "(4) SCHED ESTIMATE CONFIDENCE"
4410 GOTO 1240
5020 '
5030 S$ = "SET 7"
5040 CLONG$ = "SHIP PERFORMANCE CRITERIA"
5050 NC = 3
5060 J$(1) = "(1) OPERATIONAL CAPABILITY"
5070 J$(2) = "(2) EFFICIENCY OF OPERATION"
5080 J$(3) = "(3) FUTURE GROWTH MARGIN"
5090 GOTO 1240
5100 '
5110 S$ = "SET 8"
5120 CLONG$ = "OPERATIONAL CAPABILITY"
5130 NC=5
5140 J$(1) = "(1) PAYLOAD CARRYING CAPACITY"
5150 J$(2) = "(2) PAYLOAD EFFECTIVENESS"
5160 J$(3) = "(3) MOBILITY"
5170 J$(4) = "(4) AVAILABILITY"
5180 J$(5) = "(5) SURVIVABILITY"
5190 GOTO 1240
5200 '
5210 S$ = "SET 9"
5220 CLONG$ = "PAYLOAD CARRYING CAPABILITY"
```

```
5230 NC=2
5240 J$(1) = "(1) OFFENSIVE MISSION PAYLOADS"
5250 J$(2) = "(2) DEFENSIVE MISSION PAYLOADS"
5260 GOTO 1240
5270 '
5280 S$ = "SET 10"
5290 CLONG$ = "PAYLOAD EFFECTIVENESS"
5300 NC=2
5310 J$(1) = "(1) EFFECTIVENESS MEASURES"
5320 J$(2) = "(2) ONLOAD/OFFLOAD CAPABILITY"
5330 GOTO 1240
5340 '
5350 S$ = "SET 11"
5360 CLONG$ = "MOBILITY"
5370 NC=3
5380 J$(1) = "(1) SPEED"
5390 J$(2) = "(2) ENDURANCE"
5400 J$(3) = "(3) MANEUVERABILITY"
5410 GOTO 1240
5420 '
5430 S$ = "SET 12"
5440 CLONG$ = "AVAILABILITY"
5450 NC=3
5460 J$(1) = "(1) RELIABILITY"
5470 J$(2) = "(2) MAINTAINABILITY"
5480 J$(3) = "(3) OPERABILIITY IN EXTREME CONDITIONS
5490 GOTO 1240
5500 '
5510 S$ = "SET 13"
5520 CLONG$ = "OPERABILITY IN EXTREME CONDITIONS"
5530 NC=4
5540 J$(1) = "(1) HIGH SEA STATES"
5550 J$(2) = "(2) TEMPERATURE EXTREMES"
5560 J$(3) = "(3) FOG"
5570 J$(4) = "(4) SANDSTORMS"
5580 GOTO 1240
5590 '
5600 S$ = "SET 14"
5610 CLONG$ = "SURVIVABILITY"
5620 NC=2
5630 J$(1) = "(1) DETECTION AVOIDANCE"
5640 J$(2) = "(2) DAMAGED OPERABILITY"
5650 GOTO 1240
5660 '
5670 S$ = "SET 15"
5680 CLONG$ = "DETECTION AVOIDANCE"
5690 NC=4
5700 J$(1) = "(1) UNDERWATER ACOUSTIC SIGNATURE"
5710 J$(2) = "(2) RADAR SIGNATURE"
5720 J$(3) = "(3) INFRARED SIGNATURE"
5730 J$(4) = "(4) MAGNETIC SIGNATURE"
5740 GOTO 1240
5750 '2
5760 S$ = "SET 16"
5770 NC=4
5780 J$(1) = "(1) DAMAGED STABILITY"
5790 J$(2) = "(2) SHOCK HARDENING"
```

```
5800 J$(3) = "(3) SYSTEM REDUNDANCY"
5810 J$(4) = "(4) VITAL SYSTEM SEPARATION"
5820 GOTO 1240
5830 '
5840 S$ = " SET 17"
5850 CLONG$ = "EFFICIENCY OF OPERATION"
5860 NC=3
5870 J$(1) = "(1) MANNING"
5880 J$(2) = "(2) HABITABILITY"
5890 J$(3) = "(3) SAFETY"
5900 GOTO 1240
5910 '
5920 S$ = "SET 18"
5930 CLONG$ = "FUTURE GROWTH MARGIN"
5940 NC=4
5950 J$(1) = "(1) WEIGHT MARGIN"
5960 J$(2) = "(2) KG MARGIN"
5970 J$(3) = "(3) VOLUME MARGIN (DENSITY)"
5980 J$(4) = "(4) MODULARITY"
5990 GOTO 1240
6000 '
```

GW-BASIC Language Statements for Program DECB.BAS

```
100 'THIS IS PROGRAM DECB, Which develops the combined weighting values
101 '  for the DECISION_MAKING Criteria which were individually determined with
102 '  Program DECA.
103 '
105 COLOR 14,3
195 '
200 DIM A$(8),T(8),GT(8),J$(8),U$(50),V$(50),SUMED(8),AVGED(8),NGM(8)
205 CLOSE
300 CLS
305 INPUT "ENTER PROJECT OR SHIP TYPE IDENTIFIER: ", PROJ$
310 CLS
320 '  **********  CRITERIA SELECTION ROUTINE  ********************************
330 PRINT "******************  CRITERIA CODE LISTING  *************************
340 PRINT "Code","Title","                          Number of Sub-Criteria"
350 RESTORE
360 READ NUMCRIT                          ' Number of Criteria
370 FOR I = 1 TO NUMCRIT
380    READ CRITSYM$, TITLE$, NSC     'Criteria Symbols, Titles, # of SubCriteria
390    PRINT TAB(2);CRITSYM$;SPC(2);TITLE$;SPC(2);NSC
400 NEXT I
402 NUMCR$ = STR$(NUMCRIT)
404 IF NUMCRIT <10 THEN NUMCR$ = RIGHT$(NUMCR$,1) ELSE NUMCR$ = RIGHT$(NUMCR$,2)
410 PRINT '          Criteria Code Selection Process Begins
420 CODE$=""
430 PRINT "Enter 99 to Generate Mean Values for All Criteria, or"
440 INPUT "Enter Code Number of Criterion to be Evaluated:  ",CODE$
445 CODE = VAL(CODE$)
450 IF CODE <= NUMCRIT THEN FLAG = 1: GOTO 1050
460 IF CODE$ = "99" THEN 1010
470 INPUT "THAT IS AN INVALID ENTRY.  TRY AGAIN OR QUIT? (<T>/Q): ",Q$
480 IF ((Q$="Q") OR (Q$="q")) THEN GOTO 1710 ELSE GOTO 310
490 IF ERR=25 THEN PRINT: INPUT "PRINTER ERROR.  IS IT ON?  PRESS ANY KEY WHEN IT
IS. ", ERROK$: RESUME
500 '
1000 ' ************************************************************************
1010 FLAG = 0
1020 FOR CRIT = 1 TO NUMCRIT
1030     S$ = STR$(CRIT)
1040     IF CRIT < 10 THEN CODE$ = RIGHT$(S$,1) ELSE CODE$ = RIGHT$(S$,2)
1050 C$ = "A:\DEC\DATA\" + CODE$ + PROJ$
1055 GOSUB 4000
1058 LPRINT
1060 OPEN"I",#1,C$
1061 ON ERROR GOTO 1063
1062 GOTO 1070
1063 PRINT "THERE ARE NO ENTRIES FOR THAT CRITERION"
1064 CLOSE #1
1065 RESUME 1670
1070 TCR=0
1080 LMT=1
1090 CRT=1
1096 SUMGTI = 0
1100 RCOUNT=0
1105 LPRINT "Individuals' WEIGHTS for:   "CLONG$ "  SubCriteria are:"
1110 FOR I = 1 TO NC
1120     T(I) = 1
```

```
1125     SUMED(I) = 0
1130 NEXT I
1140 IF EOF(1) THEN GOTO 1310
1150 RCOUNT = RCOUNT + 1
1160 INPUT#1,U$(RCOUNT)
1170 INPUT#1,V$(RCOUNT)
1180 INPUT#1,LM
1190 INPUT#1,CR
1195 LPRINT U$(RCOUNT) " of " V$(RCOUNT) TAB(61) "WEIGHT"
1200 LMT = LMT*LM
1210 'CRT = CRT*CR
1220 FOR I = 1 TO NC
1230     INPUT#1,ED
1250 T(I)=T(I)*ED
1260     SUMED(I) = SUMED(I) + ED
1265   LPRINT J$(I) TAB(60);: LPRINT USING "##.####"; ED
1270 NEXT I
1275 LPRINT TAB(10) "Consistency Ratio = ";:LPRINT USING "##.####";CR
1276 LPRINT TAB(10) "Lambda Max =        ";:LPRINT USING "##.####";LM
1277 LPRINT
1280 GOTO 1140
1290 '
1300 'CONTINUE:
1310 CLOSE#1
1320 CLS
1330 ' ******** CALCULATE PROGRAM **********
1340 'CALCULATE:
1350 GLMT=0    'INITIALIZE TOTAL COUNTERS
1360 GCRT=0
1370 GOSUB 4000
1380 FOR I = 1 TO NC
1390    GT(I) = 0
1400 NEXT I
1435 PRINT "For "CLONG$" SubCriteria Weights,"
1440 PRINT: PRINT " There were "RCOUNT" Evaluators.  The Geometric Means of their
responses are:"
1450 LPRINT "The total number of respondents = ";RCOUNT
1460 PRINT : LPRINT
1480 LPRINT "The resultant Geometric Mean of the above individual evaluations of"
1485 LPRINT CLONG$ " SubCriteria Weights for the * "PROJ$" * project are :"
1495 LPRINT "                                                                NGM"
1500 FOR I = 1 TO NC
1510     GT(I) = T(I)^(1/RCOUNT)
1512     SUMGTI = SUMGTI + GT(I)
1515 NEXT I
1516 FOR I = 1 TO NC
1517    NGM(I) = GT(I)/SUMGTI
1518    AVGED(I) = SUMED(I)/RCOUNT
1520    PRINT J$(I);" Values = "TAB(58);:PRINT USING "###.####";NGM(I)
1530   LPRINT J$(I) TAB(58);:LPRINT USING "####.####";NGM(I)
1540 NEXT I
1550 PRINT : LPRINT
1560 GLMT = LMT^(1/RCOUNT)
1570 'GCRT = CRT^(1/RCOUNT)
1580 PRINT"The Geometric Mean of Lambda Max Total = ";GLMT
1590 LPRINT "The Geometric Mean of Lambda Max Total = ";:LPRINT USING "##.####";GL
```

```
1591 LPRINT
"*************************************************************************"
1595 INT CHR$(12)
1600 PRINT: LPRINT
1650 IF FLAG = 1 THEN GOTO 1670
1660 NEXT CRIT
1665 IF FLAG = 0 THEN GOTO 1690
1670 INPUT "Evaluate more Criteria for the same Project? (<Y>/N): ",Q2$
1680 IF Q2$ = "N" OR Q2$ = "n" THEN GOTO 1690 ELSE GOTO 310
1690 INPUT "Want To Evaluate Criteria for another Project? (Y/<N>):  ",Q3$
1700 IF Q3$ = "y" OR Q3$ = "Y" THEN LPRINT CHR$(12) : GOTO 300
1710 CLOSE#1
1720 LPRINT CHR$(12)
1730 END
1740 '
2000 '***********  DATA SECTION ****************************************
2010 DATA 18
2011 DATA "  1","  TOP LEVEL CRITERIA                                    ",4
2012 DATA "  2","    COST RELATED CRITERIA                                ",3
2013 DATA "  3","      Non-Recurring Costs                                ",5
2014 DATA "  4","      Service Life Costs                                 ",3
2015 DATA "  5","    SCHEDULE RELATED CRITERIA                            ",4
2016 DATA "  6","    RISK RELATED CRITERIA                                ",4
2020 DATA "  7","    SHIP PERFORMANCE                                     ",3
2030 DATA "  8","      OPERATIONAL CAPABILITY                             ",5
2040 DATA "  9","        Payload Carrying Capacity                        ",2
2050 DATA "  10","       Payload Effectiveness                            ",2
2060 DATA "  11","       Mobility                                         ",3
2070 DATA "  12","       Availability                                     ",3
2080 DATA "  13","         Operability in Extreme Conditions              ",4
2090 DATA "  14","       Survivability                                    ",2
2100 DATA "  15","         Detection Avoidance                            ",4
2110 DATA "  16","         Damaged Operability                            ",4
2120 DATA "  17","     EFFICIENCY OF OPERATIONS                           ",3
2130 DATA "  18","     FUTURE GROWTH CAPABILITY                           ",4
2140 ' ******************  END OF DATA SECTION  **************************
2150 '
4000 '#########################################################################
4010 ' *************  SELECT DATA SUBROUTINE  ******************************
4020 ON VAL(CODE$) GOTO
4030,4110,4210,4280,4350,4360,5040,5120,5220,5290,5360,5440,5520,5610,5680,5770,5850
,5930
4025 '
4030 S$ = "SET 1"
4040 CLONG$ = "TOP LEVEL CRITERIA
4050 NC = 4
4060 J$(1) = "(1) COST"
4070 J$(2) = "(2) SCHEDULE"
4080 J$(3) = "(3) RISK"
4082 J$(4) = "(4) PERFORMANCE"
4090 RETURN
4100 '
4110 S$ = "SET 2"
4120 CLONG$ = "COST RELATED CRITERIA
4130 NC=3
4140 J$(1) = "(1) RECURRING SHIPBLDG COSTS
4150 J$(2) = "(2) NON-RECURRING SHIPBLDG COSTS
```

```
4160 J$(3) = "(3) SERVICE LIFE COSTS"
4190 RETURN
4200 '
4210 S$ = "SET 3"
4220 CLONG$ = "NON-RECURRING COSTS"
4230 NC=5
4240 J$(1) = "DESIGN AND ENGINEERING"
4250 J$(2) = "PRODUCTION PLANNING"
4255 J$(3) = "PRODUCTION AIDS / TOOLING
4256 J$(4) = "DISRUPTION"
4257 J$(5) = "DELAY"
4260 RETURN
4270 '
4280 S$ = "SET 4"
4290 CLONG$ = "SERVICE LIFE COSTS"
4300 NC=3
4310 J$(1) = "(1) PERSONNEL"
4320 J$(2) = "(2) CONSUMABLES"
4322 J$(3) = "(3) MAINTENANCE"
4330 RETURN
4340 '
4350 S$ = "SET 5"
4351 CLONG$ = "SCHEDULE RELATED CRITERIA"
4352 NC=4
4354 J$(1) = "DESIGN/ENGINEERING SCHEDULE"
4355 J$(2) = "EQPMNT/MAT'L PURCHASE SKED"
4356 J$(3) = "CONSTRUCTION SCHEDULE"
4357 J$(4) = "TEST AND TRIALS SCHEDULE"
4358 RETURN
4359 '
4360 S$ = "SET 6"
4365 CLONG$ = "RISK RELATED CRITERIA"
4370 NC=4
4380 J$(1) = "(1) MATURITY OF TECHNOLOGY"
4390 J$(2) = "(2) YARD EXPERIENCE"
4400 J$(3) = "(3) COST ESTIMATE CONFIDENCE"
4402 J$(4) = "(4) SCHED ESTIMATE CONFIDENCE"
4410 RETURN
5030 '
5040 S$ = "SET 7"
5050 CLONG$ = "SHIP PERFORMANCE CRITERIA
5060 NC = 3
5070 J$(1) = "(1) OPERATIONAL CAPABILITY"
5080 J$(2) = "(2) EFFICIENCY OF OPERATION"
5090 J$(3) = "(3) FUTURE GROWTH MARGIN"
5100 RETURN
5110 '
5120 S$ = "SET 8"
5130 CLONG$ = "OPERATIONAL CAPABILITY"
5140 NC=5
5150 J$(1) = "(1) PAYLOAD CARRYING CAPACITY"
5160 J$(2) = "(2) PAYLOAD EFFECTIVENESS"
5170 J$(3) = "(3) MOBILITY"
5180 J$(4) = "(4) AVAILABILITY"
5190 J$(5) = "(5) SURVIVABILITY"
5200 RETURN
5210 '
```

```
5220 S$ = "SET 9"
5230 CLONG$ = "PAYLOAD CARRYING CAPABILITY"
5240 NC=2
5250 J$(1) = "(1) OFFENSIVE MISSION PAYLOADS"
5260 J$(2) = "(2) DEFENSIVE MISSION PAYLOADS"
5270 RETURN
5280 '
5290 S$ = "SET 10"
5300 CLONG$ = "PAYLOAD EFFECTIVENESS"
5310 NC=2
5320 J$(1) = "(1) EFFECTIVENESS MEASURES"
5330 J$(2) = "(2) ONLOAD/OFFLOAD CAPABILITY"
5340 RETURN
5350 '
5360 S$ = "SET 11"
5370 CLONG$ = "MOBILITY"
5380 NC=3
5390 J$(1) = "(1) SPEED"
5400 J$(2) = "(2) ENDURANCE"
5410 J$(3) = "(3) MANEUVERABILITY"
5420 RETURN
5430 '
5440 S$ = "SET 12"
5450 CLONG$ = "AVAILABILITY"
5460 NC=3
5470 J$(1) = "(1) RELIABILITY"
5480 J$(2) = "(2) MAINTAINABILITY"
5490 J$(3) = "(3) OPERABILITY IN EXTREME CONDITIONS
5500 RETURN
5510 '
5520 S$ = "SET 13"
5530 CLONG$ = "OPERABILITY IN EXTREME CONDITIONS"
5540 NC=4
5550 J$(1) = "(1) HIGH SEA STATES"
5560 J$(2) = "(2) TEMPERATURE EXTREMES"
5570 J$(3) = "(3) FOG"
5580 J$(4) = "(4) SANDSTORMS"
5590 RETURN
5600 '
5610 S$ = "SET 14"
5620 CLONG$ = "SURVIVABILITY"
5630 NC=2
5640 J$(1) = "(1) DETECTION AVOIDANCE"
5650 J$(2) = "(2) DAMAGED OPERABILITY"
5660 RETURN
5670 '
5680 S$ = "SET 15"
5690 CLONG$ = "DETECTION AVOIDANCE"
5700 NC=4
5710 J$(1) = "(1) UNDERWATER ACOUSTIC SIGNATURE"
5720 J$(2) = "(2) RADAR SIGNATURE"
5730 J$(3) = "(3) INFRARED SIGNATURE"
5740 J$(4) = "(4) MAGNETIC SIGNATURE"
5750 RETURN
5760 '
5770 S$ = "SET 16"
5780 NC=4
```

```
5790 J$(1) = "(1) DAMAGED STABILITY"
5800 J$(2) = "(2) SHOCK HARDENING"
5810 J$(3) = "(3) SYSTEM REDUNDANCY"
5820 J$(4) = "(4) VITAL SYSTEM SEPARATION"
5830 RETURN
5840 '
5850 S$ = " SET 17"
5860 CLONG$ = "EFFICIENCY OF OPERATION"
5870 NC=3
5880 J$(1) = "(1) MANNING"
5890 J$(2) = "(2) HABITABILITY"
5900 J$(3) = "(3) SAFETY"
5910 RETURN
5920 '
5930 S$ = "SET 18"
5940 CLONG$ = "FUTURE GROWTH MARGIN"
5950 NC=4
5960 J$(1) = "(1) WEIGHT MARGIN"
5970 J$(2) = "(2) KG MARGIN"
5980 J$(3) = "(3) VOLUME MARGIN (DENSITY)"
5990 J$(4) = "(4) MODULARITY"
6000 RETURN
```

GW-BASIC Statements for Program DECC.BAS

```
100 'This Program, "DECC" calculates and stores an individual's choice
110 ' of weighting factors for each design variant for each criteria evaluated,
111 ' and then prints out the data so it can be used in a spreadsheet program.
120 '
130 DIM A(3,3), B(3,3),C(3),E(3),CS(3),R(9),J$(9),ALT$(3) 'Dimensioning Work Arrays
140 COLOR 14,3
150 CRLIM = .2 '   set consistency factor limit
160 '
170 'MAIN PROGRAM ----------------------------------------
180 CLS
200 INPUT "Enter the Project or Ship Type Identifier                    :  ", PROJ$
210 PRINT : INPUT "Enter the design change being evaluated                    : ",
CHANGE$
300 '
305 IF ERR=25 THEN PRINT: INPUT "PRINTER ERROR. IS IT OFF?  PRESS ANY KEY WHEN IT IS ON.
", ERROK$: RESUME
310 '++++++++++++   Naming Design Alternatives   ++++++++++++++++++++++
315 FLAG = 3
316 PRINT
320 INPUT "Enter TITLE for Alternative 1 as (8 letters or less)          : ", ALT$(1)
340 PRINT: INPUT "Enter TITLE for Alternative 2 (8 letters or less)             :
",ALT$(2)
350 PRINT: INPUT "Now name Alternative 3 (8 letters) or press ENTER to bypass   :
",ALT$(3)
370 IF ALT$(3) = "" THEN FLAG = 2: DTAVAL(3) = 0
375 PRINT: PRINT "The Alternatives you have chosen are listed below:":PRINT
380 PRINT "        Alternative 1 is     " ALT$(1)
382 PRINT "        Alternative 2 is     "ALT$(2)
384 IF FLAG = 3 THEN PRINT "         Alternative 3 is    "ALT$(3) ELSE PRINT "No
Alternative 3"
385 PRINT: PRINT "Are these Alternatives Correct? (<Y>/N) :  ": Q1$ = INPUT$(1)
386 IF Q1$ = "N" OR Q1$ = "n" THEN GOTO 310
387 IF FLAG = 2 THEN NALT = 2 ELSE NALT = 3
388 IF FLAG = 2 THEN GOTO 393
389 '
390 GOSUB 2400 '   validate or reset consistency factor limit
391 '
393 CLS: PRINT: INPUT "Enter Name of Evaluator : ", FLNAME$: PRINT
394 INPUT "Enter Evaluator's Organization: ", ORG$: PRINT
395 LPRINT TAB(2)"DECISION CRITERIA EVALUATION of Design Alternatives for "PROJ$" Program"
396 LPRINT TAB(8)"Design Variant:  "CHANGE$ TAB(40) "       Consistency Ratio Limit = ";:
LPRINT USING "#.####"; CRLIM
397 LPRINT: LPRINT "Evaluation by "FLNAME$" of "ORG$"
399 '
400 '++++++++++++++++ SubRoutine "SELECTCRITERION" ++++++++++++++++++++
430 '***** Prints list of criteria from Data Section, user chooses one *******
440 CLS
450 PRINT
460 PRINT "************************ Criterion Code List ****************************"
470 PRINT "Code","Label","                        Number of Sub-Criteria"
480 RESTORE
490 READ NUMCRITE                          ' Number of Criteria
500 FOR I = 1 TO NUMCRITE
510     READ CRITSYM$, TITLE$, NSC   'Criteria Symbols, Titles, # of SubCriteria
520   IF VAL(CRITSYM$) > 9 THEN GOTO 550
```

```
530     PRINT TAB(2);CRITSYM$;SPC(2);TITLE$;SPC(2);NSC
540      GOTO 560
550     PRINT TAB(1);CRITSYM$;SPC(3)TITLE$;SPC(2);NSC
560 NEXT I
580 PRINT
700 CODE$=""
770 INPUT "Enter Criterion Code to be Evaluated:  ",CODE$
780 PRINT
790 IF VAL(CODE$) >0 AND VAL(CODE$) <= NUMCRITE THEN GOTO 4000
799 '
940 ' **************  CRITERIA CODE ERROR SUBROUTINE  ********************
950  PRINT
960 INPUT "You must enter one of the Criterion Codes to Continue (or Q to Quit) :
", CODE$
980 IF CODE$= "q" OR CODE$ ="Q" THEN GOTO 2340 ELSE GOTO 790: PRINT "Thank You"
990 ' ********* END of CODE ERROR SUBROUTINE  ****************************
999 '
1000 ' ==========  DATA ENTRY AND EVALUATION  ==================================
1002 CLS
1003 PRINT "Here are the "CLONG$" SUBCRITERIA:"
1004 FOR N = 1 TO NC
1005    PRINT J$(N)
1006 NEXT N
1007 PRINT
1010 LPRINT: LPRINT "   "CLONG$" SubCriteria Weighting Evaluation"
1011 LPRINT "-------------------------------------------------------------------
--------"
1013 LPRINT "SUBCRITERIA"; TAB(44); "DESIGN ALTERNATIVES"
1020 IF FLAG = 2 THEN GOTO 1018
1030 LPRINT TAB(44);ALT$(1);TAB(54);ALT$(2);TAB(64);ALT$(3);TAB(74);"CFACTR"
1040 GOTO 1100
1060 LPRINT TAB(44);ALT$(1);TAB(54);ALT$(2);TAB(74);"CFACTR"
1075 '
1099 '         --- select from list of subcriteria ---
1100 INPUT "WILL YOU EVALUATE EACH (E), SOME (<S>) OR ONE (1) OF THESE?  : ", SBC
1102 IF SBCH$ = "E" OR SBCH$ = "e" THEN SBCHFLAG = 0: GOTO 1315
1105 IF SBCH$ = "1" THEN SBCHFLAG = 1 ELSE SBCHFLAG =2
1110     PRINT: INPUT "Which CRITERION will you evaluate? Enter its number:  ", N
1115          PRINT: IF N > NC THEN PRINT "THE NUMBER MUST BE LESS THAN "NC".  TR
AGAIN":PRINT:GOTO 1110
1117     HD$ = "Y"
1120 GOTO 1325
1200 '
1300 ' *********  EVALUATION ROUTINE ***************************************
1305 '
1315 INPUT "WILL YOU USE HARD DATA FOR ANY OF THESE COMPARISONS? (Y,<N>) :",HD$
1320 FOR N = 1 TO NC
1321    GOTO 1325
1322 NEXT N
1323 GOTO 2300
1324 '
1325 PRINT
1330  PRINT "FOR CRITERION ";: COLOR 14,1: PRINT J$(N);: COLOR 14,3
1332 IF HD$ = "Y" OR HD$ = "y" THEN GOTO 1335 ELSE GOTO 1344
1335 PRINT:INPUT "WILL YOU USE HARD DATA? (Y,<N>)  : ", DTATYP$
1336 IF DTATYP$ = "Y" OR DTATYP$ = "y" THEN GOTO 2500
1340 '
```

```
1344 LPRINT J$(N) " Data ":LPRINT TAB(8) " ALTS" TAB(33) "DOMINANT ALT    SUP
FACTOR"
1345 FOR I = 1 TO NALT-1
1346    FOR J = I+1 TO NALT
1349  PRINT
1350  PRINT "IS ";:COLOR 14,5:PRINT "("I")";:COLOR 14,1:PRINT " "ALT$(I);:COLOR
14,3:PRINT " OR ";:COLOR 14,5:PRINT "("J")";:COLOR 14,1:PRINT " "ALT$(J);:COLOR
14,3:PRINT " SUPERIOR? ",:INPUT ": ",X
1360 IF X=I OR X=J THEN GOTO 1370
1364     PRINT: COLOR 14,4
1365     PRINT "ENTRY MUST BE EITHER "I" OR "J" ! TRY AGAIN";: COLOR 14,3:
PRINT:GOTO 1349
1369 '
1370 INPUT "FACTOR OF SUPERIORITY?   MUST BE 1 (EQUAL) OR GREATER   :  ",Y
1375 IF Y < 1 THEN PRINT: GOTO 1370
1380 INPUT "WANT TO CHANGE EITHER VALUE? (Y/<N>): ",X$
1390       IF (X$="Y") OR (X$="y") THEN GOTO 1349 ELSE GOTO 1400
1400            IF X = I THEN A(I,J) = Y
1410            IF X = J THEN A(I,J) = 1/Y
1420            IF X = I THEN A(J,I) = 1/Y
1430            IF X = J THEN A(J,I) = Y
1440 LPRINT TAB(2)"("I") " ALT$(I) " VS ("J") " ALT$(J) TAB(38) X TAB(48);:LPRINT
USING "######.##"; Y
1450    NEXT J
1460 NEXT I
1470 PRINT
1480 INPUT "ARE ALL THE ENTRIES CORRECT? (<Y>/N): ",TEST$
1485 PRINT
1490     IF (TEST$="N") OR (TEST$="n") THEN GOTO 1325
1500 FOR I = 1 TO NALT
1510    A(I,I) = 1      'Initializing array values
1520    E(I) = 0
1530    CS(I) = 0
1540    C(I) = 0
1550 NEXT I
1560 FOR J = 1 TO NALT                  'Calculating Column Sums
1570    FOR I = 1 TO NALT
1580            CS(J) = CS(J)+A(I,J)
1590    NEXT I
1600 NEXT J
1610 '
1620 FOR I = 1 TO NALT
1630    FOR J = 1 TO NALT
1640            B(I,J) = A(I,J)/CS(J)
1650            C(I) = C(I) + B(I,J)
1660    NEXT J
1670    C(I) = C(I)/NALT
1680 NEXT I
1690 '************ End of INPUT Routine **********************
1700 '
1701 ' *********  Calculate values for CR and LM  ************************
1702 LM = 0       ' Initializing Lambda Max
1703 CR = 0       ' Initializing Consistency Ratio
1704 K=1
1710 '
1720 ' ********  COMPUTE ROUTINE  ************************************
1730 ' ********  Fill the Arrays - Do the Math ************************
```

```
1740 EF = 0
1750 LA = 0
1760 FOR I = 1 TO NALT
1770    FOR J = 1 TO NALT
1780            E(I) = E(I) + A(I,J)*C(J)
1790    NEXT J
1800 NEXT I
1810 FOR I = 1 TO NALT
1820    LA = LA + E(I)
1830    IF K = 1 THEN LM = LM + E(I)/C(I)/NALT
1840 NEXT I
1850 K = K + 1
1860 FOR I = 1 TO NALT
1870    E(I) = E(I)/LA
1880 NEXT I
1890 FOR I = 1 TO NALT
1900    IF ABS(E(I)-C(I))>.001 THEN EF = 1
1910 NEXT I
1914 FOR I = 1 TO NALT
1915    C(I) = E(I)
1916 NEXT I
1920 R(1)=.01: R(2)=.01: R(3)=.58: R(4)=.9: R(5)=1.12: R(6)=1.24: R(7)=1.32
1930 R(8)=1.41
1940 RI=R(NALT)
1941 IF EF = 1 THEN GOTO 1740
1942 MU = (LM-NALT)/(NALT-1): CR = MU/RI
1943 PRINT "JUDGEMENTS ARE:"
1944 PRINT TAB(10);"FOR: ";J$(N)
1945     FOR I = 1 TO NALT
1946             PRINT TAB(15) ALT$(I);" = ";TAB(60);:PRINT USING "##.####";E
1947    NEXT I
1948 IF FLAG = 2 THEN GOTO 2000
1949 PRINT TAB(20)
1950 PRINT "Consistency Ratio = ";:PRINT USING "##.####";CR
1951 PRINT TAB(20)
1952 PRINT "Lambda Max =        ";:PRINT USING "##.####";LM: PRINT
1953 IF CR <= CRLIM THEN GOTO 2000
1954  LPRINT "THESE DATA ARE NOT CONSISTENT ENOUGH TO BE USED.": LPRINT
1955  PRINT "THESE DATA ARE NOT CONSISTENT ENOUGH TO BE USED.": PRINT
1956  PRINT "TO REEVALUATE, ENTER Y <Y>."
1957  PRINT "TO EVALUATE ANOTHER CRITERION, ENTER A (ALL DESIGN ALTERNATIVES"
1958  PRINT "    FOR "J$(N)" WILL BE GIVEN EQUAL STRENGTHS)"
1959  PRINT "TO QUIT EVALUATING "CLONG$" SUBCRITERIA, ENTER Q"
1960  PRINT:PRINT "ENTER YOUR SELECTION (<Y>, A or Q) HERE  : ": I$ = INPUT$(
1962  IF I$ = "Q" OR I$ = "q" THEN GOTO 2280
1965  IF I$ = "A" OR I$ = "a" THEN GOTO 1980
1970  GOTO 1325
1980  IF FLAG = 2 THEN E(1) = .5: E(2) = .5: CR = 0: GOTO 2000
1990  E(1) = .33333: E(2) = .33333: E(3) = .33333: CR = 0
1995 '*****************  END OF COMPUTE ROUTINE **********************
1999 '
2000 '**********************  PRINT ROUTINE  ***************************
2055   IF FLAG = 2 THEN GOTO 2070
2060     LPRINT CLONG$ " "J$(N) " Weights";TAB(40);:LPRINT USING
"######.####";E(1);E(2);E(3);CR
2065     GOTO 2080
```

```
2070   LPRINT CLONG$ " " J$(N) " Weights";TAB(40);:LPRINT USING
"######.####";E(1);E(2);:LPRINT SPC(10);:LPRINT USING "######.####";CR
2075 LPRINT "                                                    ****************************"
2077 ' ********************** END OF PRINT ROUTINE **************************
2078 '
2080 IF SBCHFLAG = 0 THEN GOTO 1322
2081 IF SBCHFLAG = 1 THEN GOTO 2300
2082 '      ---  for SBCHFLAG = 2  ----
2085 PRINT: PRINT "Here are the "CLONG$" SUBCRITERIA:"
2086 FOR N = 1 TO NC
2087    PRINT J$(N)
2088 NEXT N
2089 PRINT: PRINT "WANT TO EVALUATE ANOTHER SUBCRITERION OF "CLONG$" ": INPUT "?
(<Y>,N)   :", YN$
2090     IF YN$ = "N" OR YN$ = "n" THEN GOTO 2300
2095 GOTO 1110
2100 '
2110 LPRINT
2150 '
2300 LPRINT "-------------------------------------------------------------------
--------"
2301 INPUT "Another Evaluation for the Same Person? (<Y>/N): ",P$
2305 IF (P$="N") OR (P$="n") THEN INPUT "Start a new person? (<Y>/N): ",Q$ ELSE GOT
400
2310 IF (Q$="N") OR (Q$="n") THEN GOTO 2340
2320 LPRINT CHR$(12)
2325 GOTO 393
2330 '
2340 ' **********  QUITFILE SUBROUTINE  **********************************
2350 PRINT
2360 PRINT "Exiting this program."
2365 LPRINT C2R$(12)
2380 END
2390 '#############################################################################
2400 '
2402 ' **************  Consistency Reading Subroutine  ********************
2405 PRINT
2410 COLOR 15,3:PRINT "The data to be entered will be rejected if the data is found
to be"
2415 PRINT "    excessively inconsistent.  The limit currently set for the "
2420 PRINT "    consistency factor is "CRLIM".  To modify this limit, "
2425 PRINT "    enter ";:COLOR 14,3:PRINT "Y";:COLOR 15,3:PRINT " now.  Any other
entry will leave the limit at "CRLIM"  :  ";: INPUT "", CRLY$
2435 IF CRLY$ <> "y" AND CRLY$ <> "Y" THEN GOTO 2460
2440 PRINT: INPUT "Enter your choice for the consistency factor limit : ",CRLIM
2445 IF CRLIM < 1 THEN GOTO 2460
2450 PRINT: PRINT: PRINT "The value for consistency factor limit must be less than
1.000.  Please try again": GOTO 2440
2460 COLOR 14,3: RETURN
2470 ' *************  End of Consistency Reading Subroutine  ***************
2480 '
2500 ' **********************  HARD DATA ROUTINES  ****************************
2501 IF VAL(CODE$) < 4 THEN GOTO 2600
2502 IF VAL(CODE$) = 6 AND N = 2 THEN GOTO 2600
2503 IF VAL(CODE$) = 7 AND N = 3 THEN GOTO 2600
2504 IF VAL(CODE$) = 8 AND N = 2 THEN GOTO 2600
2505 IF VAL(CODE$) = 9 AND N < 6 THEN GOTO 2600
```

```
2506 IF VAL(CODE$) = 10 AND N = 1 THEN GOTO 2600
2507 PRINT: PRINT " BE SURE TO USE ";:COLOR 14,5:PRINT "LARGER";:COLOR 14,3:PRI
VALUE FOR ";:COLOR 14,5: PRINT "SUPERIOR";: COLOR 14,3:PRINT " CHOICE"
2508 PRINT "ZERO AND NEGATIVE VALUES ARE NOT PERMITTED"
2509 PRINT "ENTER VALUE FOR ";:COLOR 14,9:PRINT ALT$(1);:COLOR 14,3: INPUT "
",DTAVAL(1)
2510 PRINT: PRINT "ENTER VALUE FOR ";:COLOR 14,9:PRINT ALT$(2);:COLOR 14,3:INPU
: ",DTAVAL(2)
2515 IF FLAG = 2 AND DTAVAL(1) > 0 AND DTAVAL(2) > 0 THEN GOTO 2525
2520 PRINT: PRINT "ENTER VALUE FOR ";:COLOR 14,9:PRINT ALT$(3);:COLOR 14,3: INP
:  ",DTAVAL(3)
2522 IF DTAVAL(1) > 0 AND DTAVAL(2) > 0 AND DTAVAL(3) >0 THEN GOTO 2525
2523    COLOR 14,5: PRINT "INVALID DATA WAS ENTERED.  PLEASE TRY AGAIN":COLOR 1
GOTO 2500
2525 INPUT "WANT TO CHANGE ANY OF THE VALUES? (Y,<N>) :  ",X$
2526    IF X$ = "Y" OR X$ = "n" THEN GOTO 2500
2530 LPRINT J$(N) " Data" TAB(38);:LPRINT USING
"########.##";DTAVAL(1);DTAVAL(2);DTAVAL(3)
2535 A(1,2) = DTAVAL(1)/DTAVAL(2)
2540 A(2,1) = 1/A(1,2)
2545 IF FLAG = 2 THEN GOTO 2570
2550 A(1,3) = DTAVAL(1)/DTAVAL(3)
2555 A(3,1) = 1/A(1,3)
2560 A(2,3) = DTAVAL(2)/DTAVAL(3)
2565 A(3,2) = 1/A(2,3)
2570 GOTO 1500
2575 '
2600 PRINT: PRINT " BE SURE TO USE ";:COLOR 14,5:PRINT "SMALLER";:COLOR 14,3:PR
VALUE FOR ";:COLOR 14,5: PRINT "SUPERIOR";: COLOR 14,3:PRINT " CHOICE"
2605 PRINT "ZERO AND NEGATIVE VALUES ARE NOT PERMITTED"
2609 PRINT "ENTER VALUE FOR ";:COLOR 14,9:PRINT ALT$(1);:COLOR 14,3: INPUT "
",DTAVAL(1)
2610 PRINT: PRINT "ENTER VALUE FOR ";:COLOR 14,9:PRINT ALT$(2);:COLOR 14,3:INPU
: ",DTAVAL(2)
2615 IF FLAG = 2 AND DTAVAL(1) > 0 AND DTAVAL(2) >0 THEN GOTO 2625
2620 PRINT: PRINT "ENTER VALUE FOR ";:COLOR 14,9:PRINT ALT$(3);:COLOR 14,3: INP
: ",DTAVAL(3)
2622 IF DTAVAL(1) > 0 AND DTAVAL(2) > 0 AND DTAVAL(3) >0 THEN GOTO 2625
2623    COLOR 14,5: PRINT "INVALID DATA WAS ENTERED.  PLEASE TRY AGAIN":COLOR 1
GOTO 2600
2625 INPUT "WANT TO CHANGE ANY OF THE VALUES? (Y,<N>) :  ",X$
2626    IF X$ = "Y" OR X$ = "n" THEN GOTO 2600
2630 LPRINT J$(N) " Data" TAB(38);:LPRINT USING
"######.##";DTAVAL(1);DTAVAL(2);DTAVAL(3)
2635 A(1,2) = DTAVAL(2)/DTAVAL(1)
2640 A(2,1) = 1/A(1,2)
2645 IF FLAG = 2 THEN GOTO 2670
2650 A(1,3) = DTAVAL(3)/DTAVAL(1)
2655 A(3,1) = 1/A(1,3)
2660 A(2,3) = DTAVAL(3)/DTAVAL(2)
2665 A(3,2) = 1/A(2,3)
2670 GOTO 1500
2675 '******************  END OF HARD DATA ROUTINES  **********************
2700 '
2800 '
3000 '*************************  DATA SECTION  ****************************
3005 DATA 11
```

```
3010 DATA "1","     NON-RECURRING COSTS                                    ",5
3015 DATA "2","     SERVICE LIFE COSTS                                     ",4
3020 DATA "3","     SCHEDULE RELATED CRITERIA                              ",4
3025 DATA "4","     RISK RELATED CRITERIA                                  ",4
3035 DATA "5","     PAYLOAD CARRYING CAPACITY                              ",2
3040 DATA "6","     PAYLOAD EFFECTIVENESS                                  ",2
3050 DATA "7","     MOBILITY                                               ",3
3060 DATA "8","     AVAILABILITY                                           ",6
3080 DATA "9","     SURVIVABILITY                                          ",8
3090 DATA "10","    OPERATIONAL EFFICIENCY                                 ",3
3100 DATA "11","    FUTURE GROWTH CAPABILITY                               ",4
3110 '*********************  END OF DATA SECTION  *************************
3120 '
4000 ' *****  SELECT CRITERIA INFO SUBROUTINES  ******************************
4005 ON VAL(CODE$) GOTO 4030,4040,4050,4060,4210,4280,4350,4430,4600,4840,4920
4006 '
4030 S$ = "SET 1"
4031 CLONG$ = "NON-RECURRING COSTS"
4032 NC=5
4033 J$(1) = "(1) DESIGN AND ENGINEERING"
4034 J$(2) = "(2) PRODUCTION PLANNING"
4035 J$(3) = "(3) PRODUCTION AIDS / TOOLING
4036 J$(4) = "(4) DISRUPTION"
4037 J$(5) = "(5) DELAY"
4038 GOTO 1000
4039 '
4040 S$ = "SET 2"
4041 CLONG$ = "SERVICE LIFE COSTS"
4042 NC=3
4043 J$(1) = "(1) PERSONNEL"
4044 J$(2) = "(2) CONSUMABLES"
4045 J$(3) = "(3) MAINTENANCE"
4046 GOTO 1000
4047 '
4050 S$ = "SET 3"
4051 CLONG$ = "SCHEDULE PARAMETERS"
4052 NC=4
4053 J$(1) = "(1) DESIGN/ENGINEERING SCHEDULE"
4054 J$(2) = "(2) EQUIP/MTL PROCUREMENT SCHEDULE
4055 J$(3) = "(3) CONSTRUCTION SCHEDULE"
4056 J$(4) = "(4) TEST AND TRIALS SCHEDULE"
4057 '
4060 S$ = "SET 4"
4061 CLONG$ = "RISK PARAMETERS"
4062 NC=4
4063 J$(1) = "(1) MATURITY OF TECHNOLOGY"
4064 J$(2) = "(2) YARD EXPERIENCE"
4065 J$(3) = "(3) COST ESTIMATE CONFIDENCE"
4066 J$(4) = "(4) SCHEDULE ESTIMATE CONFIDENCE"
4067 GOTO 1000
4068 '
4200 '
4210 S$ = "SET 5"
4220 CLONG$ = "PAYLOAD CARRYING CAPABILITY"
4230 NC=2
4240 J$(1) = "(1) OFFENSIVE PAYLOADS"
4250 J$(2) = "(2) DEFENSIVE MISSION PAYLOADS"
```

```
4260 GOTO 1000
4270 '
4280 S$ = "SET 6"
4290 CLONG$ = "PAYLOAD EFFECTIVENESS"
4300 NC=2
4310 J$(1) = "(1) EFFECTIVENESS MEASURES"
4320 J$(2) = "(2) ONLOAD/OFFLOAD CAPABILITY"
4330 GOTO 1000
4340 '
4350 S$ = "SET 7"
4360 CLONG$ = "MOBILITY"
4370 NC=3
4380 J$(1) = "(1) SPEED"
4390 J$(2) = "(2) ENDURANCE"
4400 J$(3) = "(3) MANEUVERABILITY"
4410 GOTO 1000
4420 '
4430 S$ = "SET 8
4440 CLONG$ = "AVAILABILITY"
4450 NC=6
4460 J$(1) = "(1) RELIABILITY (MTBF)"
4470 J$(2) = "(2) MAINTAINABILITY (MTTR)"
4540 J$(3) = "(3) SEAKEEPING"
4550 J$(4) = "(4) OPERATION IN TEMPERATURE EXTREMES"
4560 J$(5) = "(5) OPERATION IN FOG"
4570 J$(6) = "(6) OPERATION IN SANDSTORMS"
4580 GOTO 1000
4590 '
4600 S$ = "SET 9"
4610 CLONG$ = "SURVIVABILITY"
4620 NC=9
4700 J$(1) = "(1) UNDERWATER ACOUSTIC SIGNATURE"
4710 J$(2) = "(2) RADAR SIGNATURE"
4720 J$(3) = "(3) INFRARED SIGNATURE"
4730 J$(4) = "(4) MAGNETIC SIGNATURE"
4740 J$(5) = "(5) ABOVE WATER ACOUSTIC SIGNATURE
4780 J$(6) = "(6) DAMAGED STABILITY"
4790 J$(7) = "(7) SHOCK HARDENING"
4800 J$(8) = "(8) SYSTEM REDUNDANCY"
4810 J$(9) = "(9) VITAL SYSTEM SEPARATION"
4820 GOTO 1000
4825 '
4840 S$ = " SET 10"
4850 CLONG$ = "OPERATIONAL EFFICIENCY"
4860 NC=3
4870 J$(1) = "(1) MANNING"
4880 J$(2) = "(2) HABITABILITY"
4890 J$(3) = "(3) SAFETY"
4900 GOTO 1000
4910 '
4920 S$ = "SET 11"
4930 CLONG$ = "FUTURE GROWTH MARGIN"
4940 NC=4
4950 J$(1) = "(1) WEIGHT MARGIN"
4960 J$(2) = "(2) KG MARGIN"
4970 J$(3) = "(3) VOLUME MARGIN (DENSITY)"
4980 J$(4) = "(4) MODULARITY"
```

```
4990 GOTO 1000
5000 END
```